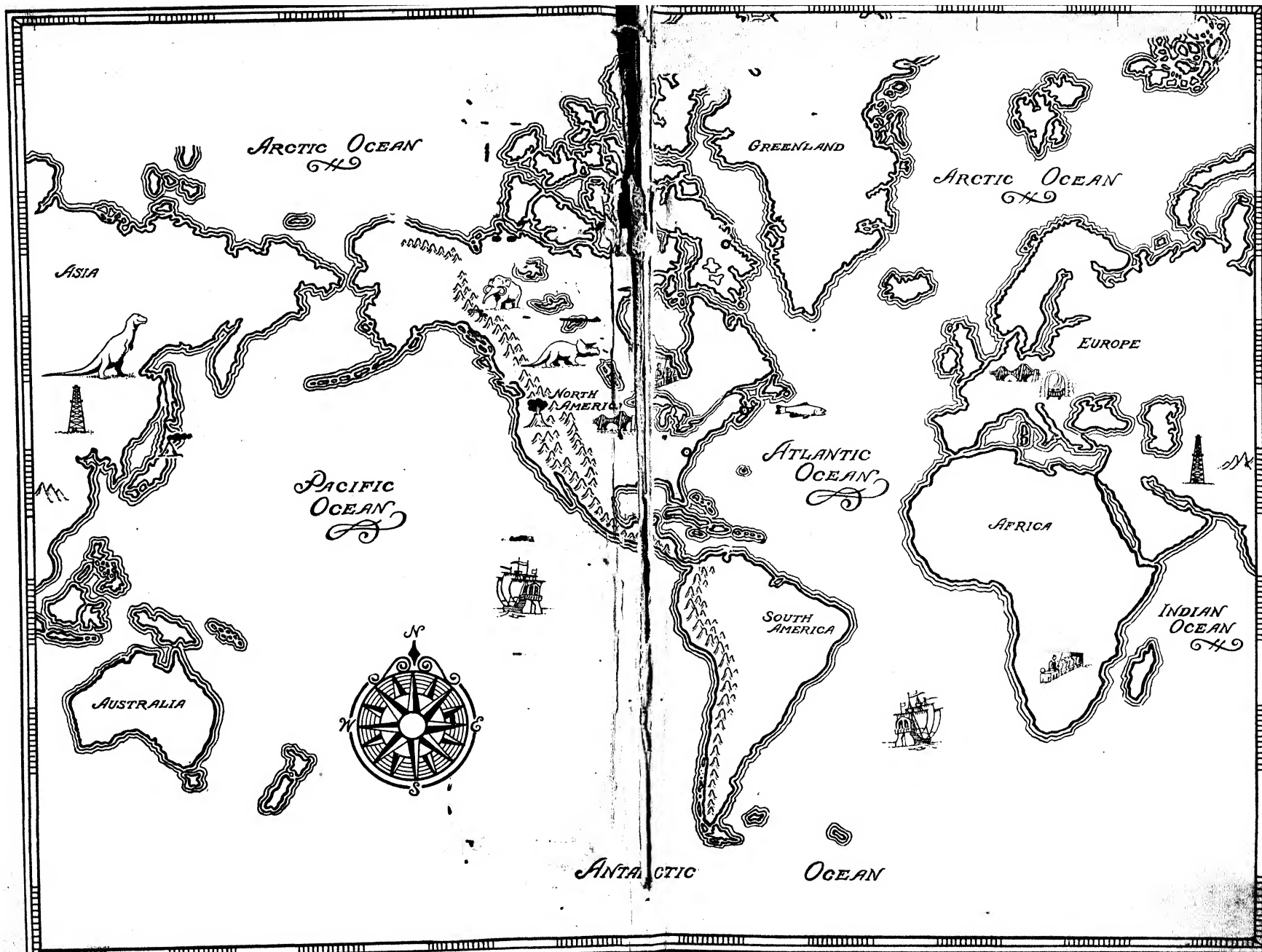


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THE EARTH BENEATH OUR FEET

By ALICE E. WILSON

Illustrated by C. E. Johnson

The story of the earth upon which we live is a very exciting one. Many geologists have spent their lives studying the rocks of the earth to learn the stories they have to tell of all the things that have happened since the earth was formed.

In *The Earth Beneath Our Feet* Miss Wilson tells these stories in a style and manner which will appeal to children. The information is authentic and up-to-date. It will make readers of this delightful book more keenly aware of the wonders of the world around them.

The first part of the book describes how the rocks of the earth were formed; how mountains were thrown up; how the plains, rivers, caves and seas of the earth were carved out; and how all of these are always changing.

The second part describes the four ages of the earth, showing how these stories may be read in the rocks of seashore, mountain and plain. The last part of the book tells the stories of the earth's treasures: gold, copper, tin, oil and gas, coal, iron, water and salt.

Here is a book which is both entertaining and instructive; a book which will stimulate in every reader a new interest in the earth beneath their feet.

THE EARTH BENEATH OUR FEET

ALICE E. WILSON

Born at Cobourg, Ontario, in the Eighties, Alice Wilson is the daughter of the late Richard Wilson, and granddaughter of William Kingston, who was head of the Mathematics and Geology Department of Victoria University, then located at Cobourg.

She spent a happy childhood with her two brothers. Their free outdoor life boating on Lake Ontario and camping in the north provided an informal education of lasting value.

Miss Wilson received her formal education at Cobourg Collegiate Institute, Victoria College, Toronto, and the University of Chicago, where she took a post graduate Ph.D. degree in geology. She was on the staff of the Geological Survey of Canada for nearly forty years, and was ranked as a full geologist at the time of her retirement in 1946.

A Fellow of the Geological Society of America and of the Royal Society of Canada, Miss Wilson has had practical experience in geological field work, and has published a number of geological maps and scientific papers. In 1935 she was made a Member of the Order of the British Empire, as the woman longest in Government Scientific service. She is now acting as consultant in petroleum geology.

THE
EARTH BENEATH OUR FEET

by
ALICE E. WILSON

Illustrated by
C. E. JOHNSON

TORONTO
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OF CANADA LIMITED

1947

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DEDICATION
TO ALL BOYS AND GIRLS

who walk and run and jump on the Earth,
this book is dedicated.

To tell you what you are walking upon,
To tell you how our Earth came to be what it is,
To tell you how it is changing now, and why,
To tell you how very old it is,
To tell you it is not the hills but the sea that is everlasting,

WARNING



N.B.— This book is like maple sugar. Read just a little at one time. Take too much and you want never to see it again. Take a small piece and you like it. You want more.

ACKNOWLEDGEMENTS

I WOULD LIKE here to express my gratitude for the time and thought given to the book by Doctors F. J. Alcock, H. Bostock, J. F. Caley, H. C. Cooke, D. Leechman, F. H. McLearn, T. L. Tanton and M. E. Wilson, geologists, palaeontologist, palaeobotanist and anthropologist. Each made a critical reading and proffered suggestions regarding the section or sections of the book in which he is a specialist. I feel greatly privileged to have been able to have the advice of these men.

I would like to thank Miss M. C. Melburn who for a number of years has taught science to children of the age for which this book is written. She read and criticized the whole book and made suggestions from the angle of the presentation to boys and girls.

I also owe a special debt to gratitude to Doctor Grace A. Stewart, of Ohio State University. The book was originally designed as a joint effort. She has given me a number of ideas and suggestions and has critically read Part One.

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THE PROLOGUE

Beauty born of law!
As when a dull grey stone
Tossed by an urchin,
Winged by force,
Lightly leaps from wave to wave,
Gently dipping, bird-like, curving low,
Scatters shining drops ere it falls
Forever to oblivion.

ANONYMOUS

"HEY, THERE! I'll show you," shouted Jim, slithering down the cliff and running across the beach.

"I know why you can't skip them," he added breathlessly, stooping to pick up a small flat grey pebble which he threw lightly over the surface of the lake.

"Five times," counted Betty, who stood beside Tom.

"I can beat you," she boasted. Opening her hand she chose a smooth flat pebble a little larger than the others and threw it 'underhand'. For Betty and Jim lived by the lake and had skipped stones ever since they could remember.

And Betty did beat Jim, by one. Her stone skipped six times.

Tom stood watching. Tom had lived in the city. The lake and skipping stones were new to him. He tried again. One skip.

"You haven't the right stones," said Jim. "Let me see them."

Tom opened his hand. Stones of all shapes were there, wet and sparkling and pretty.

"They're no good," said Jim. "You need flat grey ones."

"Why?" asked Tom.

"I don't know," said Jim. "They skip better. Look at Betty's."

Betty opened her hand full of flat, dull, grey stones, and held them beside Tom's sparkling ones. The stones looked very different side by side. Tom's were wet, round, and coloured. Betty's were flat and dull but they were the kind to skip.

"Why are stones so different?" asked Tom. Neither Betty nor Jim could tell him.

"Dad," asked Betty that night. "Why are stones different?"

"I don't know," answered Dad. "Are they?"

"Yes," said Jim, looking up from a book. "You have to use grey ones to skip, and lots of others are round, and red, or green, or white."

"Yes, that's true," said Dad. "But I don't know why."

A week later Tom was back at school in the city. He had to write a composition on summer holidays, and thought of the stones.

"Why have stones different colours?" he asked the teacher.

"Have they?" answered the teacher. "I don't know."

"Yes, you have to use flat, grey ones to skip," replied Tom.

Then Friday night came. Tom, Jim and Betty, together again, forgot about the different stones until Saturday morning. Racing down to the shore they took a short cut through an old quarry, and almost ran

into a man, with a pack on his back. He was tapping at the rocks with a queer-shaped hammer.

Something clicked in Jim's brain.

"Say, mister," he asked suddenly. "Why are stones different?"

"Are they?" said the geologist, for such he was. He paused to straighten his back and looked at the three. Now, a geologist is a person who tries to find out all he can about the Earth.

"Yes, they are," he answered himself.

"Some are flat and some are chunky," Jim continued.

"Yes," admitted the geologist. "So they are. Did you ever see these?" he asked, holding out a piece of the dull grey stone which he had just chipped from the rock. In it was a little creature turned to stone. It had a head, a body and a tiny tail, and looked a little like a crab.

"What is it?" asked Betty shyly, standing on one foot.

The man handed it to her and watched her thin eager face.

"That is a trilobite," he answered. "There is nothing quite like it living now. It was a very distant cousin of the crab."

"Was it alive?" asked Betty, her eyes wide with surprise.

"Yes," said the man.

"I have seen pieces of things like that," said Jim. The boys took it in their hands in turn.

"How did it get here?" they asked.

"That," said the geologist, "is almost the same story

as the reason stones are different. That little animal was once alive in the sea."

"Alive in the sea!" they all shouted, and then were silent.

"But, how did it get here?" asked Jim slowly.

"I will tell you," the man replied.

The geologist took the knapsack from his back and sat down on a granite boulder on the edge of the limestone quarry. Betty and the boys sat around in front of him. On one side of them the sun was shining on the blue water of the lake. Above them the sky was blue, with white floating clouds. In moist cracks between the great layers of rock grew the green, green moss. Around the scattered piles of loose stone at the edge of the quarry tumbled the sweet-smelling stalky clover. The dying blue bugloss grew up among it, faded, but still as straight as soldiers. A brilliant mass of purple asters shoved aside a bunch of withering grass. The wind fitfully lifted Betty's hair.

And this is what the geologist told them.

PART I

OUR EARTH AS WE KNOW IT

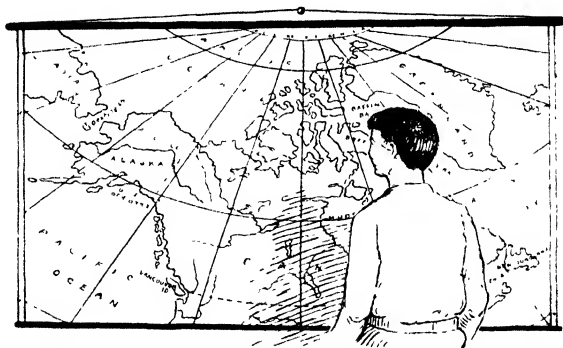
The earth is round, and like a ball
Seems swinging in the air;

Water and land upon the face
Of this round world we see;
The land is man's safe dwelling place,
But ships sail on the sea.

"The Earth"—S. G. GOODRICH

CHAPTER I

OUR EARTH—INSIDE AND OUTSIDE



OUR EARTH is a great ball, not quite round, but nearly so, made up of continents and oceans; the continents made up of mountains and plains. But our Earth was not always as we know it now.

The very Earth itself tells us the story. It is written, literally carved, on its rocks like writing on the pages of a book. The story tells us why there are now broad lands in some places and wide oceans in others, why and when the mountains rose up from the plains, why rivers are where they are, what made the waterfalls and canyons, and many other things.

All these things did not just appear, presto, like magic! Behind each of these common everyday things there is a story of great happenings. Sometimes the

story runs slowly, sometimes it moves at a dizzy, terrifying speed.

THE INSIDE OF OUR EARTH

On the inside our Earth is hot and heavy, but whether solid or liquid, who knows? Some think one thing and some the other. We cannot go very far into it to find out. The deepest mine does not go down much more than a mile. Oil wells have been drilled as deep as three miles. But even three miles is not very far. For the Earth is 8,000 miles through the centre, if you could cut it like an apple through the core.

How do we know that the Earth is hot inside? Perhaps you know some of the reasons. Hot molten lavas come bursting out from volcanoes. Hot springs spout out in fountains, or ooze from the Earth in many places. There are some in Yellowstone National Park, United States, in New Zealand, in Iceland and in many other places in the world. And, again, the deeper men go into mines the hotter it grows. So, no doubt about it! The Earth is very hot inside.

How do we know that the Earth is heavy inside? Men have instruments with which they can measure its weight. It is too complicated to tell about here. But it is known that the inside of the Earth is much heavier and more dense than the outside.

THE OUTSIDE OF THE EARTH

On the outside our Earth is cold and solid, and very uneven. Some parts are high, like the continents, and some parts are very low, like the beds of the oceans.

Wherever you may live, look at your map. I hope

you have one. If you have not, look inside the covers of this book. You see, there are six continents: Eurasia (Europe and Asia), Africa, Australia, North America, South America, and Antarctica. Eurasia is the largest, and Australia is the smallest. Antarctica is at the South Pole. It is almost completely covered by a great ice sheet or glacier, only the mountain-tops stick up above the ice. It is not shown on our map, because no people live there, though a number have explored it, Scott, Amundsen and Byrd.

And then, there are the oceans—five of them: the Pacific, Atlantic, Arctic, Antarctic and Indian oceans. They are all joined. There is much more ocean on the Earth than there is land. Almost three-fourths of our Earth's surface is ocean.

The great bays of the oceans are sometimes called seas. The Mediterranean is one that you read much about in history. It lies between Europe and Africa. There is the North Sea between the British Isles and Scandinavia, the Behring Sea between Alaska and Russia, and the Caribbean Sea between North America and South America. There are many more. Look at your map and see how many you can find.

Why are there continents in some places, and oceans in others? Some men think that when the hot Earth cooled it shrank. The outside wrinkled like the skin on an old dried orange or apple. They think the wrinkles on the Earth are the higher parts or the continents, and the lower places between the wrinkles are the ocean beds. Others think that the continents are high because they are made of lighter rock (and they are), and that the oceans are low because beneath them is a heavy

dense rock (and there is). But no one knows all about it yet. Later I will tell you of some of the other ways in which men explain the continents and the oceans. First I want to tell of the surprising things we do know, about how our Earth was made and to find how very long it has taken for our Earth to become what it is now.

CHAPTER II

OUR EARTH'S ROCK FOUNDATION

(There are two kinds of rock)

DID YOU ever take a motor-car trip? Or, perhaps you have gone on a train journey. Almost everywhere you see rock sticking out from beneath the soil. Here it is in great cliffs, there it is flat, farther on it is in the bank of a river, or, in another place a little lies in the bed of a brook.

There is just one kind of country where you will not see rock, sooner or later. That is when you cross a great plain. When you get thirsty driving over the dusty plain, perhaps you get out at a farmhouse for a drink. The farmer's wife will bring you a glass of cool fresh water from a pump. The man who made that well bored his drill down through the soil right into the rock itself, until he found water. It had gathered in the cracks of the rock. And so, even beneath the plain there is rock. It is not seen because it is covered by soil.

The truth is rock everywhere forms the hard crust of the Earth. It is on the surface in some places. It is slightly covered with soil in some places. And it is deeply buried in some places. But there it is.

Do you know that all the rock of the Earth belongs to one of two great groups—rock that has been melted, or rock that was laid in sea-bottom?

MELTED ROCK

Rock melted! Yes, it is true! But it needs a terrific heat to melt it!

Have you ever seen a volcano, or even a movie picture of one? If you have, you know what rock looks like when it is melted. The lava, thick like molasses, flows down the mountain-side. Lava cools quickly in the air, and forms a glassy material, not clear like window glass, but dark, shiny and brittle, with sharp edges when broken. Such is lava.

But there is another story about melted rock. Sometimes, deep down in the heart of the Earth, the hot melted rock pushes up towards the surface but cannot reach it. There is no way open. As it works up and up, it cools slowly, very slowly and finally, while still below the surface it becomes solid rock. This rock cooled slowly far below, is not smooth and shiny but is made up of many particles or grains.

What happens if you boil toffee too long? When it cools it is not smooth as toffee should be, but is sugary. Grains of sugar! They are crystals—crystals of sugar. Look at them carefully with a magnifying glass, if you have one. All the crystals have the same colour, and even more surprising, they all have the same shape, except when broken.

Now the hot, thick, melted rock forms grains, too, when cooled far down in the Earth. These grains or crystals are minerals. In the slow cooling, silently and mysteriously, every crystal of each mineral takes on the same shape and the same colour. There are many different minerals in the rock. So there are many, many crystal shapes and colours.

So, these slowly-cooling rocks are called the 'crystalline' rocks. They are massive, immense and very strong. When broken they make great irregular boulders. Even smaller pieces will still be irregular, all shapes and sizes. Even the little pebbles will be uneven and made up of various mineral crystals.

Probably the melted rock which you know best is granite. It has several minerals: quartz, feldspar, mica, and maybe hornblende. The quartz is whitish and oily-looking; the feldspar is white or pink; the mica is dark and shiny; and the hornblende is black.

Most crystals are very, very small and have several sides. Some of them have many sides. You will need to get your magnifying glass for this. Each tiny side is something like a mirror. It will throw back light, like sun shining on water. That is why pebbles from these rocks are bright and sparkling. That is the kind of pebbles Tom picked up. They are beautiful, but do not 'skip' well.

But all melted rocks, whether they have cooled quickly, or cooled slowly, are called 'igneous' rocks. 'Ignis' is the Latin word for 'fire'. And it certainly needs fire to melt rock!

SEA-LAID ROCK

And then there is the other kind of rock! Rock that has been laid in sea-bottom! How do we know it was? You will see later, when reading of the 'Footprints of the Sea'. In some places this sea-laid rock is limestone. In some places it is sandstone, just the usual sand on the shore cemented into rock. Or, in some places it is shale, just the mud that has collected on the floor of

the sea, partly hardened into a weak kind of rock. Most sea-laid rocks are dull-looking. They may be almost white, grey, brick red, or even almost black. They never sparkle, except perhaps some bits of the sandstone.

Do you live near a quarry, or near a shore where some of this flat-lying rock is on the surface? Try to break it. Give it a strong blow with a hammer, straight down! Pretty tough, isn't it?

Well, try the other way, from the side, horizontally.

It breaks! Quite easily, in fact.

Why does it break one way more easily than the other? Because it was laid in that way, flat on the sea floor, layer upon layer.

Take that piece you have broken off. Break it into smaller pieces. The edges are jagged, not round and smooth like pebbles. But they are all flat. They would 'skip' on the water. Jim and Betty knew them. Try them. When pebble edges are smooth and round, it just means that the sharpness has been worn off by jostling around with other pebbles.

ROCKS THAT ARE CHANGED

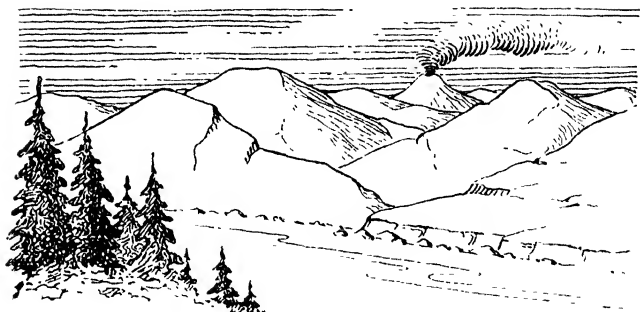
Sometimes both sea-laid rocks and melted rocks are changed again. The hot melted rock in many places has shoved and burned through the sea-laid rocks, and burns or cooks the parts it touches. The changed rock is called by a big name—metamorphic rock. It is really quite simple. It just means a rock that has changed its form. Marble is a changed limestone, that is all.

So, there are the two great groups of rock—that which was once melted, and breaks into irregular bright sparkling pieces; and that which was laid in sea-bottom and breaks into dull, flat pieces which wear into round flat pebbles.

And remember, that the Earth's crust everywhere is made up of rock, though in some places the rock is covered by soil.

CHAPTER III

**MOUNTAINS COME AND
MOUNTAINS GO**



They crowned him long ago
On a throne of rocks, in a robe of clouds,
With a diadem of snow.

LORD BYRON

WHAT MAKES mountains? For mountains, you know, were not always where they are now. Some mountains are very old and some are quite young. Another strange thing is that the oldest mountains are not the highest. Two of the oldest mountain regions in the world are the Highlands of Scotland and the Laurentians in Canada which lies across North America from the Atlantic Ocean to Lake Winnipeg and north to Great Bear Lake. These very old, old mountains are not nearly so

high as the Rockies or the Alps. And yet the Rocky Mountains and the Alps are really quite young—for mountains.

How do I know? I will tell you. Or better, you can find out for yourself, if you live near the mountains. There is probably a quarry, on the mountain-side, somewhere near you. There nearly always is one. Go and look at it. You will see the rock lies in layers. That, you have learned, is because it was laid down, one layer flat upon another, in the bottom of the sea. We must talk more about that later. But you see, if this rock was once sea-bottom it must have been very much lower and not mountain-side at all. Yes, it was lower. What is true of your mountain-side is true of all other mountains. All the great mountain ranges of the Earth once were not mountains at all.

WHERE ARE THE GREAT MOUNTAINS?

Where are the great mountains of the world, to-day? Wherever you may live, look at your map. There are mountains on all the continents and even on many islands. In North America and South America they run nearly north and south near the edges of the continents. In Europe and Asia most of them run east and west. Africa is near Europe and shaped something like North America and South America. On the north of Africa where it is near Europe the mountains run east and west, too. In the rest of Africa the mountains are more like those in North and South America. They run almost lengthwise, near the great oceans. The African mountains are not so high as the Rocky Mountains and the Andes. As to Australasia it is a little difficult to say.

They are north and south on Australia itself, but everywhere around it there are so many drowned mountains. All those islands are just drowned mountains, with their tops above the ocean.

A MOUNTAIN CLIMB

Let us go for a walk up a mountain to see what it really is! Here in the valley it is green. Beneath the green is the soil of the fields. This path leads upward. And there is forest beginning near the foot of the mountain. We seem to be walking on woodsy-covered earth, just as in any other walk through the forest. Don't trip on those boulders along the path! I wonder where they came from? There is a break in the trees over there, and here is a trail leading that way. Let us follow it around the bend.

The trees are thinning out now, and there are bits of cut limestone strewn along the trail. Yes, there is the quarry, with its walls of layered rock. Well, one thing seems certain. Here is some of the limestone that has been laid under the sea.

Let us go back to the main path again. The trail is getting rougher and steeper. There is less soil and more boulders. There are side trails here and there, but let us stick to the one we are on. It is narrower now, we will have to go single file. Look! We are on the edge of a cliff. We can see far down the valley and over the flat countryside. See all the farms down there! And a town! See the smoke from that crawling train! Right beneath our feet is a great ridge of massive rock. It is no longer the layered rock, but the igneous type, hard and strong, the kind that was once melted. You can

hardly split it even with a hammer. So, we see, our mountain is not all made of layered rock. Crystalline rock is part of the mountain, too.

There is much rock here, but also there are forests on this mountain-side. If we did not follow the path, we should be lost in the 'bush', at least on the lower half of the mountain. In spite of the boulders and great shoulders of rock there must be soil here, too, though we cannot see much of it for the dead branches, moss, dead leaves and rock. But the soil is here, caught in the hollows between the great rocks.

So we have learned there is ordinary soil on the mountain-side in which trees grow.

But it is getting late. We cannot climb to the top, but we can look at the summit of our next mountain neighbour with the field-glass. Can you see it?

What makes the mountain-top so jagged? It is rock, all rock, sharp and steep. Not much soil there! It could not stay very well on that steep slope. Rain and melting snow would wash it down. There are no trees there either. They could not grow without the soil, and, besides it is cold for trees on mountain-tops.

What, then, are mountains? They are masses of rock piled high, sea-laid and igneous rock. They are steep and rough. They have soil on the lower part, and in the soil live growing plants and trees. Mountains, then, are like the rest of the Earth, only they stand on end, their peaks far above the green valleys.

FROM WHERE DID THE MOUNTAINS COME?

The hills are shadows and they flow
From form to form, and nothing stands;
They melt like mist, and solid lands,
Like clouds they shape themselves and go.

LORD TENNYSON

Why are these rocks piled up so steeply, above the plains? How did the sea-laid rocks ever get there? Were these mountains once at the bottom of the sea? They were. You saw for yourself the layers of rock on the mountain-side in the quarry.

All the wise men who have studied the rocks puzzled and puzzled over that question. They measured the thickness of the layered mountain rocks. Some worked hard at measuring and comparing the rocks of the Alps. Some worked in the Rocky Mountains, a few in South America, a few in Africa. They wrote about it. They gathered together and talked about what they had found. And this is what they thought.

When the highest layered rocks now on the mountains were below, on the bottom of the ocean, then the lowest layered rocks must have been many feet below the water.

Imagine seas where there are now mountains! Look at your map. The seas must have been in the broad valleys or troughs all up and down the continents, just where we now have mountains! There must have been such a trough or valley along the margins of North America and South America, and in those other countries, too. The ocean waters must have poured into those valleys. They must have, because to-day there,

on the mountain-side, are the many thousands of feet of layered rock.

It is true! Rock was laid on sea-bottom all over these broad valleys just as long as the ocean filled them.

"But," you say, "that would not look like North America and South America, nor Europe. It would not be the right shape!"

But it was so. All the shores have changed. You and I would not know a map of North America then. It was so different.

The wise men pondered. How did the mountains rise from the sea?

"That means that the continents rose or the oceans sank!"

"Well," they said, "we know the solid bottom of the ocean is really heavier than the land. So far so good!"

"Then," they thought, "the mountains have risen, when the heavy floor of the oceans sank, and the ocean water that had filled the former valleys drained out."

And that, some of the wise men thought, is what happened! The continents rose when the oceans sank. Things happened! The Earth was shaken to its core! The sinking floor of the ocean shoved against the edges of the land. Those rocks shoved the rocks farther inland, shoved and shoved. The continents were pushed up until the wide sea-covered valleys were raised and the sea-water ran out again to the great oceans, leaving broad stretches of young sea-laid rocks that were weak. The ocean floor sank farther. The rocks were crushed and shoved still farther. The new sea-laid rocks just crumpled up. They were piled up and up, as the margins of the continents were pushed inland. The

rock broke. It piled up on edge. Great pieces slid over and buried other pieces. You know, if you live near a mountain, because you can see them, the layers piled up, sloping or shoved over one another.

It is true that long ago the Pacific Ocean did sink. It drowned many of the islands. Such sinking sometimes happens now. A very few years ago a little piece of the floor of the Pacific Ocean dropped farther down, when the earthquake shook Long Beach, California, and caused a great amount of damage. Long ago the Atlantic Ocean sank, too, but not so far. It is not so deep. The Arctic Ocean and the Indian Ocean sank, and even the much smaller Mediterranean Sea. It did not happen all at once, as I have told you, but bit by bit.

The Strange Doings of Continents

Later another thought was born. Cut up a map of the world. Place the continents side by side, like pieces of a jigsaw puzzle. South America fits right under the sheltering bulge of Africa. Move North America a little around the North Pole and it fits against Europe and Asia. Cut off India and slide it down against the east side of Africa. Place Antarctica, Australia and all the other islands, those not too small to handle, to the south and east of Africa and India.

They fit rather well. Think, then, of all the continents as one huge continent. In the chinks that do not quite fit, think of shallow seas upon this one great continent.

So, it once stood, one man thought — a German, named **Wegener**. Many others agree with him. Wegener risked and lost his life trying to find out about this and other questions referring to it. Wegener died dur-

ing a Greenland winter, measuring the growth and conditions of glacial ice, and the possible movement of separation of Greenland from North America. Others are still trying to find out whether his theory could be true.

Wegener thought, then, that all land was once one. Then the continents, as we now know them, floated apart!

Continents float! Well, not exactly, certainly not in the waters of the oceans. Then how did they 'float'?

We know that the rocks beneath the oceans are heavier than the continents. We know, too, how glaciers move. They do not flow. They re-crystallize. The great weight from higher up makes heat. A tiny liquid film forms over one end of the crystal, on the side of least pressure, and then the liquid film freezes again, but it has moved a tiny bit along its own crystal. So each crystal moves on, film by film, by the freezing and thawing of one after another of each tiny particle of each ice crystal, though always, the whole great mass is solid. This sometimes is called 'solid flow'.

So also solid rock, if crystalline, can move under great, unequal pressure. When pressure is equal on all sides the rock is rigid. Thus, thought Wegener, the continents moved with their bases in a heavy dense rock beneath, which itself was anchored in the solid core of the Earth. So, he thought, North America and South America moved from Europe and Africa. So, Asia and India moved together. Antarctica moved west, and Africa moved from India and Asia and all moved from Australia, and Australia itself moved, too.

And, as the Americas moved westward in a century-

slow ploughing through the heavy rocks below, their western margins were wrinkled up into mountains. As Asia, India and Africa pressed together the long line of mountains, the Alps and Himalayas, were crushed up between them. Northward and westward they all moved, but some perhaps moved faster than others.

Why did they move? What would move them? The mighty but slow force of the turning Earth. As the Earth turns through the ages it bulges at the Equator where the speed is greatest. So the continents would move out towards the place of greatest speed, move westward and northward.

Could this be so? It will take many observations and many years to prove it right or wrong.

But that is not all! Whichever way the mountains were formed, certainly things happened! Some of the rock, always hot down in the heart of the Earth, melted and welled up, pouring into the cracks, sometimes beneath the surface, sometimes out over the surface. Or the molten rock belched out as terrible volcanoes. As it cooled, the melted rock hardened or 'froze', like cooled toffee. This did not happen just once, but many times.

And so, probably in one of these ways, the great mountains of the Earth were formed. They are made up of melted rock and of sea-laid rock.

This is the story of the younger mountains like the Rocky Mountains, the Andes, the Alps and others.

THE VERY OLD MOUNTAINS

It is very difficult to read the story of those very much older mountains, the Laurentians in Canada, the Adirondacks in New York State, for instance. The Ad-

irondacks really are a border part of the Laurentians. These mountains are all so very old. The tops of these old, old mountains are all worn off, so they are not so high now as they once were. But men found that they, too, were not always mountains, because there are layered sea-laid rocks among them: sandstone and limestone and shale. It was all so long ago that the oceans and continents may have been quite different. Scotland is still surrounded by the ocean that may have wrinkled up the Highlands, but some parts of North America where those ancient mountains stand are now far inland. Men are still wondering. That is a question for you to think about and work about, when you are older. It is a big question and worth while.

MOUNTAINS MADE BY VOLCANOES

And then there are mountains that have grown and grown from little volcanoes to big volcanoes. There are active volcanoes and dead ones. Active volcanoes belch out smoke and steam, and sometimes lava. Lava is really melted rock. It pours out of an opening, called a crater, at the saucer-shaped top of the volcano. Sometimes the lava wells up out of cracks on the sides. It cools or 'freezes' on the outside of the volcano. First it builds a little cone-shaped hill, then it piles more lava on top of the cooled lava, and builds up higher and higher. The mountain you see in so many pictures of Japan, Fujiama, grew in that way. There is a very beautiful mountain in Chile, Osorno, just like that, and there are many others in the world.

Sometimes a big volcano explodes. Then things happen! Terrible things, if there are people living on its

sides, or in the valleys! Melted rock bursts from the sides of the volcano, and blazing gas and hot ashes are hurled into the air, and the ash falls all around burying everything. Some of the ash is shot high above the Earth and carried far away on the upper currents of air. Ash from a volcano has been carried all around the world.

Sometimes a volcano will be quiet for years, then there is a rumble and trembling of the Earth, and it will burst out again, just like Vesuvius did in Italy. It came to life in a hurry. Steam burst out and blew off the top of the mountain. Ashes and lava covered the country for miles around, burying people and whole towns.

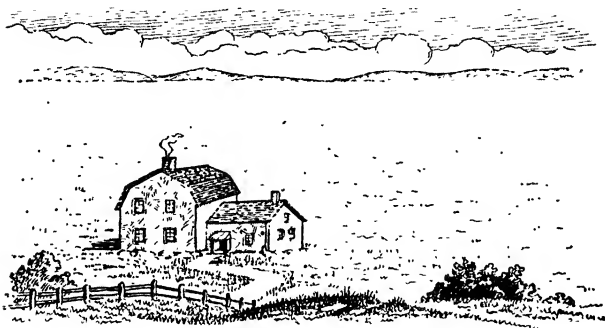
And then there are dead volcanoes, dead for years and years, perhaps hundreds of years, perhaps thousands of years, or much more. There is volcanic ash in a great many of the old rocks. Some rock in Wales has shells right in the volcanic ash, showing that the ashes fell into the sea. Mount Royal at Montreal, Canada, is the core of an old volcano. There are old volcanoes in Yellowstone Park, Wyoming. And the hot geysers there show it is still hot beneath. There were even volcanoes in the very, very old rocks of the Laurentians, because there are old lavas there.

* * *

And then there are mountains which are not made the same way at all. They were really plains at first.

CHAPTER IV

PLAINS COME AND PLAINS GO



NOW THE MOUNTAINS stand high. Their peaks in the clouds seize and hold our imagination. But the mountains cover only a small part of the Earth. The broad vast parts of the Earth are the plains. They cover the greater surface of all continents. There, on the plains, is where people live. The cities of the plains! They are the great cities of the Earth.

In the days of old, what people sometimes call 'the brave days of old', capital cities were built on mountains, or in high places. Can you think why? The enemies of their people could not get at them easily. But even then the rich cities were on the plains. Why? One reason is that they were the centres of great farming areas. Where land is fertile, there people must live.

Another reason is that some of the cities of the plains were the centres of the great trade roads, whether trade was carried on by camel or by ship. But trade has changed. Camels and sailing ships have given place to trains, motor trucks, and great oil-driven ships. To-day some of the great cities on the plains are also ports. London is both a city of the plains and a great port. New York and Montreal, the two greatest ports of North America, are not cities of the plains, but Chicago is. Chicago is also a lake and river port, but it began as a city of the plain.

The cities of the plains are often factory centres. The electricity used to run the factories may come from waterfalls in the upland or mountain rivers, but it is cheaper to carry electricity to the factory than to carry goods over mountains. So the factories are on the plains.

A plain is not always level like the surface of a pond. It may be uneven. Some plains may have low hills. Others have long ridges of rock. Some plains are low. Some plains are high above sea-level.

There are many plains. In the United States there is a plain on the east, sloping to the Atlantic Ocean, a great plain of the Central States drained by the Mississippi River, and others in the west. In Canada there are plains in large parts of Ontario, in the wide-spread Prairie Provinces, and in the north country where the cariboo range. In Europe there is the great plain of Northern Russia. There are the desert plains of Africa, and the veldts of South Africa. There are broad plains in South America, such as the great wheat fields and cattle ranges of Argentina. A large part of the centre of Australia is a plain.

Why are these great stretches of the Earth plains? How did they come to be so level? Just as the mountains were not always mountains so the plains were not always plains. Plains are made by water; by running water in rivers, by the waves of lakes and ocean; in a few places by volcanoes pouring out lava; and in a few places by the pushing up of great blocks of the Earth's crust.

RIVER-MADE PLAINS

Do you live near a river, where you can see its valley? If you do not, just look at a fast little stream near you. See how it washes its sides away, then spreads the sand and mud along its bed. A large river does exactly the same thing. It may take a long time, but it does it. The rather flat part of the river valley gets wider and wider. Sometimes, like the Mississippi and the rivers which flow into it, the river overflows its banks and spreads the sand and mud far and wide on the top of the valley it forms. The Nile in Egypt does that, too, and many other rivers. The river makes a plain grow. Such land is very fertile, as you know if you live on a river plain.

WAVE-MADE PLAINS

But perhaps you live by a seashore, on the California coast, south of Monterey, or on one of the Great Lakes. For lakes though smaller really work as hard as the ocean. Stand up high on the cliffs and look down.

There is a narrow ribbon of shore away down there between the cliffs and the sea. The sea beats against those great cliffs and breaks off pieces of them. On quieter days the tide coming in and out spreads the stones, the sand and the mud along the strip of shore.

The strip becomes wider, and wider, and the level stretch with a gentle slope grows farther and farther out under the water.

Beaches like this are very narrow plains. But after a long, long time the wave-worn strip of beach grows wider and wider still. It becomes not a beach but a wide plain. The cliffs, far inland now, are hills. The rivers coming from those hills, lend a hand. Together the waves and the rivers have made a great, gently sloping, almost level stretch of land between the sea and the inland hills. This is called a coastal plain. All this time the ocean has been smoothing out its floor along the coast. Finally a great plain stretches from the hills away inland far out under the sea, part of it on land and part beneath the sea.

Perhaps you live in the east Atlantic States and know some part of the great plain that slopes from the Appalachian Mountains to the sea. Perhaps you live in England where the plain slopes from the mountains of Wales to the North Sea. Perhaps you live—Well, there are quite a number of other places you may live and be on such a plain. It would really take too long to name them all.

Then something happens, not suddenly, but slowly. The land begins to rise, up and up. The shore of the sea moves farther and farther out. Slowly it moves. The land still rises! The shore still moves farther out! And there is a great plain! There are such plains now hundreds of miles from the sea. That has happened many times since the Earth began. How do we know? The base of the plain is made of sea-laid rock. Perhaps you live in Wisconsin. If so, you are living on a plain

which once was beneath the sea. Perhaps you live in the Prairie Provinces of Canada. They, too, were raised from beneath the sea. It happened all along Lakes Erie and Ontario. Parts of these plains in some places are drowned by their lakes, but there they are, still plains beneath the water.

PLAINS THAT BECOME MOUNTAINS

Now as soon as a great plain like this is lifted up, immediately, the rivers get to work. They begin to pull it down. They wear valleys here. They wear valleys there. Finally the valleys meet and a piece of the high plain is left standing alone like a mountain. It really is one kind of mountain. The Catskills of New York were made in this way. So were the Helderbergs of New York. They are what is left of a high plain. The Cotswolds and Chiltern Hills of England and quite a number of mountains are made in that way. They are parts of high plains not yet worn down.

HIGH PLAINS BECOME LOW PLAINS

The winds help the rivers to wear down the plains. Hand in hand they wear the high plain away until it is cut into sections. In the west of the United States these small bits that are left are called 'mesas'. They are flat on top because they were part of a plain. 'Mesa' is the Spanish word for 'table'. In Arizona some of the Indians live on these flat-topped mesas.

But the rivers, helped by the winds, never stop working until the mesas, too, are quite worn down, and behold! You have another plain, a low level plain this time. It has been worn down from a high plain by the rivers and wind.

So the rivers work and work, wearing the land away. They make two kinds of plains: first, in their own valleys by wearing down their sides and spreading the muds and sands over the broadened valley; second, by wearing down high plains into low plains. And the oceans work and work, wearing down their shores, making beaches and spreading the muds and sands over their floors, to form a part of a larger plain if the land rises. They just never stop working, night and day, rivers and oceans.

The Circle

This story really goes around in a circle. The river carries sand and mud and rock from the mountains and spreads them along the shore. The waves break off the edges of the shore and add sand and mud and rock to what the rivers have brought down. The shore widens, the floor of the sea becomes level. Then it rises into a high plain. Then the rivers begin all over again. That is called a 'cycle', which means it is repeated over and over again like the turn of a wheel.

During the time the plain is high it is called a 'plateau'. That is the French word for a 'high flat place'.

MOUNTAIN PLAINS

But there is another kind of high plain or plateau. It is hard to know whether to call it a plain or a mountain. You know now how mountains are made. Sometimes the force of the mountain-building movement is so great that the crust of the Earth is twisted and pulled, until it is broken up into great blocks. Two blocks may fall, and as they fall, squeeze up another between them. That squeezed-up block will make a great flat-

topped plateau, too. There are a number of plateaux formed that way in the United States, in Oregon, and parts of Nevada and in California. Immediately the rivers and winds get to work to wear down the edges. By and by they look like any other mountains, but they were not formed in exactly the same way. They were plateaux first. (The 'x' at the end of 'plateaux' is not a mistake, that is the way French words ending in 'eau' form their plural.)

LAVA PLAINS

There is still another kind of high plain or plateau, the kind that has been made from lava. Down in South America, in Peru, and thereabouts, there was once an old mountain range, worn down pretty low, for mountains. Farther inland the newer higher Andes were pushed up, and many volcanoes began to awake. They got very wide awake, indeed, and active, and poured out lava, and poured it out. Not only did it come from the saucer-shaped crater at the top, but the mountain-sides burst open. Lava flowed down filling the valleys until the old mountains nearer the coast were completely covered. Slowly the lava hardened, and now there is a high plateau in Peru, covering the old mountains, and nearly all made from lavas and other volcanic materials. Rivers from the high plateau have cut through the rock and revealed the old mountains buried by the later lavas. There is another plateau like this along the Columbia River in Oregon, Idaho and Washington States.

So, besides the low plains made by the wearing down and the levelling-off of rivers and oceans, there are the plateaux or high plains that have been lifted up, the

plateaux made by pushed-up blocks, and the plateaux of lava.

So the mountains and the plains come and go.

It is not the hills that are everlasting but the sea!

CHAPTER V

THE TWINS THAT ARE EVERYWHERE



HERE IS A RIDDLE! What are the Twins-that-are-Everywhere? They were here, there and everywhere when your grandparents were boys and girls, and when their grandparents were boys and girls, and many hundreds of years before, almost since the Earth was made. They are still being born, now! Who or what are they? They are sand and mud! Did you ever hear of any place without them? They are twins, really twins. They even look alike sometimes, do they not? What are they really?

When you were very little, you made mud-pies. You poured water on some mud and stirred it with a stick, or perhaps you just used your hands. What is this mud you used for your mud-pies?

Do you have a garden? If you have, get a handful of soil. Look at it carefully. Put a little into a glass of

water and see what happens. Some of it will float on top. Skim it off. Some of it will sink quickly. Leave it in the bottom of the glass. And the rest, just muddy water, pour carefully into another glass. Let it stand long enough to dry out. Something is left in the bottom of the glass, very tiny particles.

Now you have three things. One, the part that floats is dead roots and leaves broken up very fine. There is really only a very little. Two, the part that sank quickly—that is sand. Not much of it in your garden, I hope! Too much of it is not good for your flowers. Three, the part that made the water muddy, is clay. When it is wet we call it mud.

SOMETHING ABOUT SAND

Let us look at the sand first. Shake it in the glass of water. Hold the glass up to the light. The water is clear. The sand is at the bottom. That is the first thing we learn about sand. It is heavy, and sinks quickly to the bottom, leaving the water clear.

Leave the sand in the water a few days, weeks, or even months. It will not disappear. It remains the same. That is the second thing we learn about sand. It does not disappear or dissolve in the water.

But its colour! Look at it in the water. It is bright and sparkling, and there are all sorts of beautiful colours—white, pink, red or purple. That is the third thing we learn about sand. It is bright and sparkling and full of colour.

SOMETHING ABOUT CLAY

Let us look at the clay. Put some of it, not too much, in a glass of water. Shake well. It makes the water 'muddy', doesn't it? If you have good eyes you will see

tiny specks floating around in the water. Look at it with a magnifying glass. The particles do not float on top like the specks of roots and leaves. They are heavier. They float right down in the water. That, then, is the first thing we learn about clay. It almost floats, but not quite.

Let the glass of muddy water stand. The particles slowly settle to the bottom. No matter how long it stands the clay will not disappear into the water as salt or sugar will. That is the second thing we learn about clay. It will not disappear or dissolve in the water.

In time the water dries up. Look at the clay left in the bottom of the glass. It is dull-looking, isn't it? Unless you live in New Brunswick, or Niagara, or Georgia or some other place where the clay is a brick-red colour. In those places it is red because there is iron in it. But even there it is a dull red. That is the third thing about clay. It is dull in colour.

The twins, then, are alike in that neither of them dissolves in water. They differ in that sand is heavy though bright and sparkling, and the clay almost floats, but is a dull colour.

HOW SAND AND CLAY ARE MADE

From where did these strange everyday twins come? For they are strange, are they not, even if they are so very common! Yet, they were being made when the Earth was very young. They are being made to-day.

The Streams and Rivers Make Them

I saw sand and clay being made one day. I was walking up a trail on the side of a low mountain in Quebec. Near the path was a large stone, all rounded at the

corners, a boulder of coarse-grained rock, broken from the hillside. It was quite sparkling in the sunshine. In a ring around it on the ground were coarse bits which had flaked off. Up there, in the winter it is very cold. Each year, when the cold autumn rains fall on the coarse boulder, the water freezes in the cracks. The ice loosens the outside flakes which gradually fall off. On the ground these pieces look like coarse pebbly sand. In the springtime the snow melts and floods down the hill. The snow-water carries some of the coarse flakes with it. The floods of another spring carry them to the stream below the hill. They lie at the edge of the stream. A thunderstorm may flood the stream. The pebbly flakes are pushed a little farther downstream. They bump against the bank and rest a year or two. And so it goes, day after day, year after year.

But all this time something happens to the pebbly flakes. They are becoming smaller and smaller. Part of each flake disappears in the water, just like salt. And there is salt and lime in those old rocks, and many other things that will melt or dissolve in water. It takes a long time, but it happens. Then the pebbly flakes fall apart. They become smaller and smaller as they move down the stream.

So the pebbly flakes are divided in three. First, the salts are carried away, dissolved in the water. Second, little particles that do not dissolve are broken off and carried downstream, floating or almost floating in the water; that is the clay. Third, the heavier bits that do not dissolve are rubbed and scrubbed along the shore. They jostle against one another, grinding off their edges and corners. These particles are the sand.

Almost every stream you look at is carrying mud and sand to the sea. That is why the water looks muddy. Such is the work of streams all over the Earth, to carry the loose rock materials to the sea. They never rest. The Mississippi River carries so much mud and sand to the sea that it has built up a great delta at its mouth. So has the Nile River, and the Mackenzie River. The Amazon and St. Lawrence rivers carry their sand and mud far out to sea. Their channels are deep. Their currents are strong.

The flakes I saw on the hillside that day will move down to larger and larger streams until they reach the Ottawa River, and then down the Ottawa for many years to the St. Lawrence River. And then down, down to the Atlantic Ocean. It will be a long time before they reach the ocean, perhaps thousands of years, but they will get there.

The Winds and the Rains Make Them

But not all of those pebbly flakes I saw that day will get into the stream. In fact, my heavy boots tramped some of them into the ground. Always the moisture in the ground gets to work immediately upon the salt and lime in such broken flakes, and they begin to change. During summer, when there is less rain, they dry out. Along comes a hot wind before a storm and blows them along the side of the mountains, away from the stream. The pieces scurry along tumbling over one another. A rainstorm comes up and beats the flakes into the damp ground. More of the salts, and minerals in them dissolve and each piece falls apart, just as in the water. They dry out again, then again along comes the wind.

Day after day the winds blow and blow. The coarser heavier particles are rolled along the ground, they bump against the rough places in their path, and stop when the winds die. The finer particles are blown far away. When the winds cease the finer bits lie just where they are, far beyond the coarse heavy particles. And so, the coarse pieces become finer, and the finer pieces become still finer. And finally they are all sorted out. The rain-water has carried the salts into the ground. The very, very fine pieces, the clay, is blown far away. The coarser sand is piled in dunes nearer the starting-point. But this time the sand is not rounded by rubbing. It is sharpened, and has edges, because when the wind hurls sand grains, one against another, each sharp, heavy piece just chisels off the sides of its neighbour.

So the pebbly pieces that are not carried into the stream make sand and clay, too. The great sand dunes of the Sahara desert, in Africa, have been formed in this way. On the desert of Peru are great crescent dunes of finer sand, sorted out from the coarser, heavier sand on the floor of the desert.

The Ocean Makes Them

Sand and mud are being made in other ways. Do you live near the ocean, or near one of the Great Lakes of the world? I hope some of you do. The waves of the ocean, particularly in storms, are breaking off bits of rock which are slowly ground up. During heavy storms the stones are hurled at the cliffs, breaking off still more rocks. They, too, are slowly ground up, year after year. The mineral salts are dissolved in the water, the lighter tiny pieces float or almost float away, the heavier sand

is dropped nearer the shore, making sandy beaches. So the lakes and oceans are making sand and mud.

* * *

So, now we have three ways in which sand and mud are being made right under our eyes. In each case the Twins come first from rock. The rock is split, by frost or waves or by the dissolving of the salts in them. The large pieces become smaller and smaller by the further dissolving of the salts. The parts of the rock that cannot be dissolved are carried away by streams or wind or waves. The Twins-that-are-Everywhere are being made now.

SAND AND MUD MADE LONG AGO

But not all the sand and mud on the Earth has been made recently, or when your grandfather lived, nor even since man has lived. We must look back, before that, far back.

If you read on, in Part II, you will find the story of the Great Rhythm of the Earth. Many times the sea came up over the continents, and then went back again to the ocean beds. As the sea came and went the rivers changed. Every river, every ocean storm, every downfall of rain through all those many millions of years was making sand and mud, all the time. They just never stopped.

But something else was happening. At the same time the oceans were working in another way. Each time as the sea came up covering the sand and mud already lying on the continents it cemented some of the sand into sandstone and some of the fine clay particles were pressed into shale. So, not all the sand and mud was left to be carried by the streams or to be blown by the wind.

So now we have it all. The sand and mud which is being made to-day is added to that made during all the many millions of years in the past.

Do you wonder that they are the Twins-that-are-Everywhere, and that there is so much of them?

CHAPTER VI

RIVERS AND THEIR VALLEYS

The streams all flow into the sea
But the seas they never fill
Though the streams are flowing still.

Eccles. I, 7. (Moffat Translation)

HAVE YOU EVER WONDERED why there are so many rivers on the lands of the Earth? Why some are so small and others so large? Where they begin and where they end? Almost every boy and girl in North America has seen at least one little river. If you live in the country you must know a stream that flows into a river. If you live in the mountains you know how the mountain brooks chatter down the slopes. Even if you live in the city probably there is a large river flowing through it or very near it.

RIVERS NEEDED BY MAN

From the earliest time man has used the rivers. Before there were roads, rivers were the highways for travel and trade. Before there were trains there were boats; boats that were poled along; boats that sailed; or boats driven by a paddle wheel. Then there were steamboats, and finally the great steamships of to-day. In North America canoes were first used by the Indians. And it was along the rivers that the early discoverers in our country explored the land.

The first white men to go down the Mississippi River were Frenchmen from French Canada. They had to

paddle miles westward, up the rivers flowing into the St. Lawrence. When they could not go farther they picked up their canoes and carried them through the woods to the next river. The French word for 'to carry' is 'porter'. So the places over which they carried their canoes became 'portages'. Finally they found one of the rivers which empties into the Mississippi and paddled down it to the great 'father of waters'.

And now we travel quickly over the country by train or automobile, and still more quickly through the air. But boats still travel on river and lake, and a great deal of the merchandise of the world is still carried on boats down the rivers to the seaports.

RIVERS RUN TO THE SEA

Have you read *Water Babies*, by Charles Kingsley? If you have not, read it. During a storm Tom saw the eels and everything rushing past him. "Down to the sea," said Tom, "everything is going to the sea, and I will go too." And the same thing is true of all the brooks, streams, little rivers and big rivers, too. All are going to the sea.

Why do rivers flow to the sea? Well—because that is their work—to carry all the waters of the Earth to the sea. They flow to the sea because the sea is the lowest place, and water always runs downhill. A river along its course may twist and turn and flow in the opposite direction for some distance, but always it will turn again and flow on to the sea.

"But all the water does not go to the sea," you say. "Water soaks into the ground, and there are swamps and lakes." Give it time and it, too, will get to the sea. When rain falls, part of it soaks into the soil. But it

does not stay there. It often moves on below the ground and if there is an opening it will flow out again as a spring. The spring may join a river. Swamp water, too, may join the water hurrying to the sea. Even the water in the lake may get to the sea. Look at your map again. Rivers carry the water down from one lake to another lake, and then a larger river carries it down to the sea. See for yourself on the map. The Nipigon River carries the water of Lake Nipigon to Lake Superior, the St. Mary River carries it to Lake Huron, the St. Clair River carries it to Lake St. Clair, the Detroit River carries it to Lake Erie, the Niagara River carries it to Lake Ontario, and the St. Lawrence River at last carries it to the sea.

There is only one condition in which water does not flow to the sea—that is, if it is below sea-level. Of course it could not flow then because it would be flowing uphill. It seems very odd but there are really places on the continents which are lower than the sea, for example, the water near the bottom of some of the deep lakes. The floor of several of the Great Lakes of North America is too deep for the water caught there to flow up into the sea. Death Valley in California is lower than the sea but of course there is not much water there to flow out. When the water cannot flow out of small seas or lakes on the land it becomes very salty. Great Salt Lake in Utah is a very salty lake. So is the Dead Sea in Palestine.

A RIVER IS BORN

Do you live on a farm with a little stream flowing through it? Does the stream begin in a swamp back of those fields, or, does it just begin in a ditch in the pas-

ture field? It gets a little bigger on this side of the field. Do you know why? Some of the water that soaked into the ground on that hill over there is coming out in a spring, not bubbling, just slowly oozing out. It gradually makes its way down to the stream. So it makes the stream larger.

If you live near the mountains you will have to climb up high to find out where the rivers are born—away up near the top, at the edge of the snow and ice. Perhaps you can find a stream along the mountain-side which runs not from the snow but out of a hole in the rocks. It really started higher up in the snow but disappeared into a crack, and is coming out again as a spring.

But, you who live on a farm, where did the water come from that began in the pasture ditch? Yes, from the rain.

And, you who live in the mountains, where did the snow and ice come from? From the rain and sleet.

The rain from the clouds, then, is the mother of the streams whether they begin in a pasture field or in the mountains. They are really born from the clouds.

THE BABY STREAM GROWS

At first our stream is just a baby stream. Out in the pasture field it dries up when the summer sun is hot. But it struggles on after the next rain. Let us follow it. Within a little distance a few small springs join it. There is more water now. It will not dry up so quickly. Now it passes another ditch which brings the water from those other fields over there. It does not take long for it to become so big that it never dries up, but flows along the same course all the time.

Why does it always follow in the same course? It begins in a low-lying spot, a ditch or hollow, where some water has collected. After heavy rain the water runs a little faster, and hurries along picking up and carrying along bits of sand and soil, from the bottom and along the banks. So the stream cuts its bed deeper and wider. The ditch is now a ravine or little valley. And the valley, in turn, holds the stream within its banks.

Now the valley changes as we go along. The banks become quite steep. They are not smooth but are cut by deep gullies. What made the gullies? When it rained last time the rain came down so fast that it could not soak into the ground. It poured over the edge of the bank, right into the stream we are following. A great deal of sand and soil was carried down from the side. Gullies are formed and each time it rains they get bigger and bigger.

And, by the way, have you noticed something more? The stream's bed is very much deeper than it was farther back? There is more water. It is carrying along more sand and soil from the bottom, cutting deeper into the earth. The stream is full of pep and energy, just like boys and girls. It hurries along, and keeps cutting away at its banks and bed. It is a 'young river'.

But, look here! The stream has cut right through the soil. Here is some flat rock at the bottom. It is much harder to cut through rock than through sand and mud, so the water has spread out wider here. Let us go farther down. Another stream, quite a large one, has come in over there. Streams like this that come in from the sides we call 'tributary streams'.

RAPIDS AND CANALS

The stream is really quite large now. I think we can call it a river. See, the water is running swiftly and it is quite rough. There are big rocks and boulders which make the water dash up. This is a 'rapid'. The water is not deep enough to cover all the bottom. These rapids make a lot of trouble if the river is big enough and deep enough for boats. The boats would be dashed to pieces on the rocks and large boulders. So men build canals, man-made rivers, right beside the true river. They cut them deep enough and wide enough to carry the boats. Then they turn some of the river water into them. Men thought of this long ago. Because in olden days there were no automobiles, and no trains, they learned to use the rivers. When the rivers had rapids men had to think of some way to get past them. And indeed almost all rivers of any size have rapids somewhere along their course.

In some places rivers turn and twist so much that canals are built connecting two points on the river, cutting off the twists and turns and shortening the route. In other places canals are built to avoid going around a great piece of land like a continent. One of the great canals of the world, the Suez, connects the Mediterranean Sea and the Red Sea. It was built, not to avoid rapids but to make a shorter route from Europe to Asia, to save going all the way around Africa. This is a very important canal because most of the trade between Europe and Asia passes through it. The canal is built in the low places where Pharaoh's horsemen and chariots were drowned when they tried to capture the fleeing Israelites.

One of the most important canals in the western hemisphere is the Panama Canal, built to make a short way from the Atlantic to the Pacific Ocean. Not many years ago ships from New York or England had to go far down to the southern tip of South America to get to San Francisco or anywhere on the Pacific. Between Central America and South America there is a very narrow strip of land, an isthmus. The mountains that run down through North America and South America are not very high there. On one side a few streams drain into the Atlantic, on the other some drain into the Pacific. And there is a large lake. So men built the Panama Canal there, using the lake and the rivers on both sides as much as possible. Now ships go through this canal instead of going all around South America.

A GORGE!

But let us get back to our river. We have passed the rapids and the river is flowing more smoothly now. It has actually cut into the rock. Cut the rock! Yes, it is true. See! The channel is narrower now and the water is flowing swiftly but quietly. Let us follow it down. The water is so busy cutting down that it does not have time to cut widely. And see! It is rolling those stones a little, near the edge. They are regular cutting tools. Some of them are probably scraping along the bottom, wearing it away, cutting it deeper. After a big thunderstorm they will go on scouring the bottom at a great rate, cutting it very quickly. And here they certainly have cut it deep. The river bed is down between two walls of rock. This is a 'gorge'. The word 'gorge' means 'throat'. The river is flowing through a narrow channel like a throat.

There are many gorges like this in the rivers of the

world. One of the best known in North America is the Niagara Gorge. Maybe some of you have seen it.

A CANYON

But come, let us go on. There is another river coming in on that side, right through another gorge. Our main river which we have been following is very large now. It can do a lot of work, cutting deeper and deeper. We are now far down between these walls of rock. Let us climb up to the top. We can see better from the edge. The sides are pretty rough to climb but if we try hard enough we can get up.

As we climb we notice that the valley is getting wider. That means it is wider at the top than at the bottom. Be careful of those loose pieces of rock. They may start to roll if you step on them and you will fall. Try this path. Here is some water trickling down. This must be a spring. And the rock is all crumbly around the spring. For even this water is helping to wear the rock sides away. And a big storm will certainly carry a lot of the loose rock down into the river. Indeed, that is the reason the valley becomes wider as we climb higher. Much broken rock is carried down the steep slopes by the rains. And, of course, a lot just falls down of its own accord.

The valley wall is not just straight up but rises step by step. Just like stairs! Do you notice the softer rocks are worn away more rapidly than the hard ones? The harder layers hold up and form the steps. Here we are on top! This is better. Now we can see. The river looks like a little thread far down below. It twists and turns in its rock-walled sides. This is no narrow throat now. This is a great deep valley, a *canyon*—a great canyon.

There are many canyons in the world. Canyons in Europe, canyons in China, canyons in Africa, the Peace River canyon in Canada, the Yellowstone and Columbia canyons in the United States. But perhaps the greatest of them all is the Grand Canyon of the Colorado River in Arizona. The Colorado River cuts down through almost every kind of rock: limestone, sandstone, shale, igneous rock—a mile deep, down, down into the hard granites away beneath. It is a very long canyon, 200 miles. And the rocks show so many beautiful colours: red, yellow, green, grey, purple and pink. Most of these bright colours are from iron, like the iron rust with changing shades.

All rivers do not have canyons, only those with swiftly flowing streams where their valleys are in hard rock. They are usually formed in mountains or in high plateaux, where the streams go down many feet to reach the lowland.

A LAKE!

Have you noticed while we have been walking and talking, that we have been gradually coming down from the highland? It is not so far down to the bottom of the canyon here. And in front of us, not far below, is a broad plain. The river comes out of its rock-walled canyon to the plain. And look! It is very crooked now. It seems to wander all over the plain.

The river is slower now. It has time to spread out. We cannot see very far because there are so many trees. But look carefully and you will see a lake away over there. There is very little rock now. It seems to be covered with very fine clay or silt, called alluvium.

Let us follow the river to the lake. Look! on the

other side of the lake over to the west, another large river is flowing in. There are some rocky islands in the lake. We must get around to the other side to find where the water runs out from the lake. For this lake is higher than the sea. The water must still flow on.

Here is the river carrying the water out. Miles away from where it entered! I suspect men call it by a different name here. They generally do. It is flowing on, steady and deep. Big ships should be able to steam up and down this river. I wonder if they do?

NOW A WATERFALL

Come on! The river is flowing faster now. And look, it is rougher. This is almost a rapid again. The water runs very swiftly. What is that peculiar noise? It is almost a roar! Nearer and nearer it comes. Louder and louder! I wonder if there is a waterfall? See! The smoke! No, it is not smoke. It is mist. Sure enough, there is a big waterfall ahead. Down the water goes; smooth and swift over the centre part, fretted along the sides.

We will have to go down along the bank. We cannot possibly go down over the fall. Of course, we did see some little waterfalls farther back. There were some from the little streams dropping over rock ledges entering the river at the rapids. And there were others in several places, but none like this. This looks terribly high as we look up at it. Why, it must be some hundred feet or more, all in one great drop!

There are really many great waterfalls in the world. Perhaps the best-known one in North America is Niagara Falls. The water plunges over a cliff in the Niagara River, and drops 160 feet straight down. There are

many falls with a greater drop than this. But very few of them carry so much water. Look at your map. See how the water from Lake Erie flows into the Niagara River and then all of it just drops down that cliff, swirls around the Whirlpool Rapids with terrific force, and flows swift and deep down to Lake Ontario.

Then there is Yosemite Falls in California. It drops from a great height, about a third of a mile. But there is not so much water and it spreads out in a falling mist. And then, about the greatest fall in the world is the Victoria Falls on the Zambesi River in Africa. But not many people have seen them. At least, very few white people. But it may be some day they will be as well-known as Niagara Falls.

THE VALLEY GROWS WIDE

But now our river has travelled down to a broad, level plain. It spreads and winds. It flows slowly because its course is not so directly downhill. The sides of its valley are far back now. But they are there. And the river is carrying down the mud and sand from these low far hills which it does not even touch.

"How in the world can the river do that?" you ask. "Can it not carry away only what is washed into it?" Well, here the valley is so level the river is not cutting deeply. It gradually takes a bit of its bank here, and another bit there. And the streams that drain into it do the same. It is making its bed wider. And as a bit of soil is carried away its place is filled by another bit slipping from the bank above. Farther back still more soil moves on. Sometimes it is carried by rain, sometimes it just drops over a tiny slope when the soil beneath has been removed. And so the valley grows back

and back to the distant hills. The soil fairly creeps down to the stream, slowly, very slowly.

FLOOD PLAINS NEAR THE END OF THE JOURNEY

But we were down in the level valley of our river, were we not? There will be cities there and farms. When the river has passed all its gorges, canyons, and waterfalls, if it has them, and reaches the low level part of its valley, it flows more slowly. And then something new is likely to happen. When the rain comes pouring down during the rainy season the slow river cannot carry away all the sand and mud that is carried into it. It flows over its banks and spreads all the material over its valley floor. This is its flood plain. It is built up by the sand and mud which the river puts there. There are usually people living on the flood plain. They like to live there. The rich alluvial or river soil grows fine crops. It is easier to build houses on the flat land. That is why there are fine farms and great cities on the flood plains of great rivers.

But when the floods come it is very bad. Sometimes whole towns are flooded and people have to flee from their homes. Houses are carried away by the swirling waters, crops are ruined, and people are drowned. The flood plain of a river is a pretty dangerous place when there is a flood. If any of you live on the flood plain of the lower part of the Mississippi River you know all about it. Or if you live on the plain of rivers that run into it, like the Ohio and Missouri rivers, you will know about floods too.

PORT NEAR THE SEA

And now we are almost at the sea. There is a great city here. It is not right at the mouth of the river, but

a few miles upstream. Why? Because the wide mouth of the river makes a harbour. Here ships from all over the world might come, bearing merchandise of the east and the west. There must be plenty of room for the ships. If the city were at the very mouth the ships would have to stay along the shore. It is better up the broad bay which often forms at the mouth of a great river. The storm waves will not keep swinging the ships against the piers as they load and unload. New Orleans, near the mouth of the Mississippi is such a city; so is New York on the Hudson, London on the Thames in England, and Buenos Aires on La Plata in South America. London is the biggest port of them all.

LAST, THE DELTA

But we have not quite finished with our river yet, even though it has at last flowed into the sea. When the slow-flowing water reaches the sea it stops. In the still water beyond the mouth of the river all the sand and mud it has carried from its banks settle to the bottom. Year after year they fall. After a long time they will build up islands at its mouth. Such islands are called the 'delta' of the river. Altogether they have a shape something like the Greek letter called 'delta'. It is the same as our letter 'd' but it has a different shape.

All rivers do not have deltas, just as all rivers do not have canyons. It depends upon how fast they flow, what kind of country they have passed through, and what the shore-line is like when they meet the sea. The St. Lawrence does not have a delta. It is deep and strong, and has not flowed through low plains. It is still deep far out into the ocean, and so the sand and mud are carried far out. But the Mississippi has a large delta.

It is so large that there is a big lake on it. The Mackenzie River has a large delta where it flows into the Arctic Ocean. The Nile River in Egypt has a very famous delta. It is the fertile Land of Goshen, and upon it the very old city of Alexandria is built.

And so we have come to an end of our river.

WHAT IS A RIVER'S VALLEY

And now we must pause and look back. All along you remember, springs, brooks, streams, and other little rivers kept bringing their water into our river from different directions. They drained the land of its water and brought it to the river. We passed down the stream for miles and miles. That vast piece of country that drains into our river is its valley or its basin. Sometimes we say the Mississippi valley and we mean all the great expanse of the Central States. We say the St. Lawrence River valley, and we mean all the country in the United States and Canada that drains into it. Sometimes we include in that all the country, away inland, that drains into the Great Lakes as well. For the water that runs into the Great Lakes passes to the Atlantic through the St. Lawrence.

And then there is the Amazon River in South America. Away up in Peru, only a few hundred miles from the Pacific Ocean, I watched water flowing between the mountains, and knew it flowed eastward for thousands of miles, down to the Amazon, and on to the Atlantic Ocean. It was a part of the Amazon valley. And there is the Nile River the valley of which reached far back into Africa; the Mackenzie which flows for hundreds of miles north to the Arctic. There are many other large rivers. Just look at your map to see some of them.

CHAPTER VII

CAVES AND CAVERNS

In Xanadu did Kubla Khan
A stately pleasure dome decree;
Where Alph, the sacred river, ran
Through caverns measureless to man,
Down to a sunless sea.

Kubla Khan—SAMUEL TAYLOR COLERIDGE

A JOURNEY THROUGH A CAVE

A CAVE! A magic word! The word 'cave' comes from the Latin word 'cavus' meaning a 'hollow place'. And you will understand the reason, because we are going underground into a cave to find out about it.

We must take a lantern, a shovel, and a fish net. This is not a really modern up-to-date cave, with a paid guide. So we must go prepared like real explorers. And do not forget to bring a big ball of string. What for? You will see. We will go into the cave from an opening in the mountain-side. The string can be fastened to that rock at the opening. Firmly, for much depends on it. We unwind it as we go. Now, light the lantern. There are no electric lights here. Already it is becoming dark. When we look back we see that the opening through which we came is getting smaller and smaller. It has become a mere speck of light. Now it has vanished completely.

It is quite cool and dry here, not far in. And see, there are a few bones. Animals of some kind must have been here at one time. We have heard before that some

animals, like bears and wolves, take shelter in caves for a short time. In ancient times some primitive men lived in caves before they learned to build houses. Here, not very far from the opening where it is dry, it would be very comfortable, never too hot, nor too cold. It would be a good place to hide from one's enemies. In many caves in Spain and France, and in Africa and other places, bones and skeletons of ancient man have been found. These cavemen made drawings and painted pictures on the stone walls. They can still be seen in many of the caves. They show the reindeer, elephants, bison, and other kinds of animals that early man knew.

Our cave is very black now. The lantern makes just a small round glow of light. The darkness beyond is thick and sounds hollow. We are going downhill here. The space is narrower. Here is a turn. The string must be unwound at every step, but carefully, for a sharp corner might rub through and cut it. Then we would be in a fix. You know now why we need the string—to guide back to the opening.

We are not the first to use a string for that purpose. A string had been used as a guide so far back in time that the method is part of a Greek legend. In the centre of a great Labyrinth of intricately winding passages King Minos of Crete kept a monster, the Minotaur, with the body of a man and the head of a bull. To the Minotaur the king was sacrificing seven maids and seven youths of Athens. Theseus volunteered to be one. Now Ariadne, the daughter of Minos, loved Theseus. She was sure he would kill the Minotaur and gave him a ball of thread to find his way out again. Theseus killed

the monster, found his way out by means of the thread and took Ariadne for his bride.

But to come back to our cave! Here is a very narrow place. It is almost filled with soft clay. This is where we need the shovel. It is hard to dig out this passage. It is so narrow! Beyond it the way goes down, down into the blackness. On and on through long passages that twist and turn in and out, and round about. Here is another very narrow place. Can you squeeze through? What was that sound? Did you hear it? Like little scuttling feet! Many small animals probably live in here. We are invading their homes. Rats and mice, spiders, insects of many kinds, and snails and many other creatures would find this a fine place to live. And do not forget the bats, the upside-down bats, which hang head downwards in the dark caves in the daytime. At night they fly outside for food. Bats like darkness. They cannot see well in the light. Animals that live in caves become especially fitted to live in the dark. Some may live near the openings where they can get out for food. But others live away back in the cave all the time.

Listen to the sound of our voices! They seem different. They have a hollow sound. Voices have that lost, hollow sound in large empty rooms. This must be a large room. Yes, the lantern shows the rock roof far above us. Some caves are very high, much higher than this one.

In the famous Carlsbad Caverns in New Mexico one room is 250 feet high. That is much higher than Niagara Falls.

What a weird sound is made by the echoes! It is black as night where we are now. There is a great

dome, almost a hill, in front of us. Let us go around it. Everywhere the floor is very uneven, all sorts of lumps and bumps, and pillars big and little. Careful! We may stumble over them in the dusky light, if we are not cautious. The path is slippery in places, too, because of the water that has dripped, seeping through the sides. Listen! the steady drip, drip, drip! Down, down we go through lofty rooms and still more winding passages, down into the heart of the Earth, it seems.

Around this bend there is a curtain-like mass of rock, with fringed edges hanging in front of us. Stoop or you will strike your head on it. The lifted lantern shows a fairyland! Gleaming white rope-like curtains of 'travertine' hanging from the walls! Farther over, on that side, there is a great curtain hanging from the ceiling. It hangs fold on fold, white and gleaming, with water slowly dripping from the fringed edges down to the floor. On this side the curtain almost touches a pillar of travertine rising up from the floor. In one place they meet and make a solid wall.

Let us break off a tiny pencil-like piece, here at the edge. It will probably be hollow. And it is. As we turn the light slowly the colours change with the glistening lights and moving shadows. The silence seems to press it upon us. What a relief to hear the dripping water in the distance! I wonder if there is a lot more water over there? We shall see later.

STALACTITES HANG FROM THE ROOF

How does the water get down here? We did not see it running in at the opening. Well, it soaks or seeps down through cracks and crevices from all the country round about. As it comes, bit by bit it slowly

dissolves some of the lime in the rock through which it passes. The lime is dissolved just the same way that the salt is dissolved in the glass of water, but much more slowly.

What happens to the water when it comes down into the cave? Some of it dries up. It passes out of sight into the air. And what becomes of the dissolved limestone in it? Of course, the water cannot carry that into the air. It is left behind, just as the salt was left in the glass when the water dried. Men call this cave-made limestone 'travertine'. You remember we saw some of it farther back. The word comes from a Latin word meaning 'tibertinus' from the land of Tibur, in Italy. There are great quarries of travertine there.

As the water dries on the roof of the cave it leaves a small ring of travertine. Another drop slowly dries, leaving another ring. Then another and another. A little pencil of travertine is formed. Another drop slowly rolls down over the pencil. Sometimes this is called 'drip-stone'. Each drop that dries leaves its tiny ring, one upon the other. It goes on and on through the ages until finally a long hollow icicle of travertine hangs down from the roof. Sometimes a single one will grow longer and longer, many feet in length. These travertine icicles, hanging from the roof or ceiling, are called 'stalactites'. The word is from the Greek word 'stalasso' meaning 'to drip'.

The stalactites may grow and grow, longer and fatter, until they touch one another and form a broad curtain, with small pencil-like icicles hanging from the bottom like a fringe. Where the travertine-filled water

drips slowly down the walls the icicles grow together in great curtain masses like tapestries.

STALAGMITES RISE FROM THE FLOOR

Of course, not all the water dries up as it trickles through the roof and down the stalactites. Some of it drops to the floor. There, too, some of it dries. First a tiny ring is formed. Then more and more rings. It builds up slowly into pillars. Sometimes they are just bumps, but sometimes they grow into high mounds. They are all called 'stalagmites', whether big or little. That is another word from the Greek word 'stalasso', to drip. Sometimes stalagmites grow to be many feet high. You remember that great dome we saw in the room a little while ago. That is a stalagmite. In the Carlsbad Caverns there are many large stalagmites. One is called the Giant Dome. Another is known as the Rock of Ages. These big stalagmites took many thousands of years to grow.

As we go farther along in our cave the travertine has collected like frozen waterfalls in some places. The water has been flowing over the rock here. Before we leave this fairyland let us move the lantern around slowly on all sides. Take a last look at this strange and wonderful place.

POOLS OF WATER IN THE CAVE

But let us go on. There must be still more sights to see. We must go carefully and not slip or step in a shadow. There might be a crevice or even an opening to another room below. If they are out of range of our lantern light we cannot see them. The string must still be used so that we can find our way back.

Still farther down into the blackness we go. The drip-

ping water sounds now as though it were not dripping onto the floor, but into some more water. The tinkle of it echoes and re-echoes. What is this reflection? Why, sure enough! A pool of water! How green the water is. This must be at the bottom of the cave, for pools, and even small lakes form in the lowest parts of caves in some places. In some caves there are even rivers at the bottom. In the great Mammoth Cave in Kentucky, there are two rivers. One is called the Styx, because it is deep and black, like the river over which Charon ferried the souls of the dead to Hades. The other is Echo River. We need not tell you how it got its name. For you know the sound of our voices has been echoing back and forth as we have been walking along.

BLIND FISH LIVE IN THE CAVE

Did something move in the water? Over there? Why, yes! A little fish, white and tiny. Our fish net now. Why, the fish is blind! This is not really surprising. We remember that animals that are born and always live in the dark are likely to be blind like this after many generations. They never have a chance to use their eyes, so they lose the power to see.

There are many blind fish in Mammoth Cave. They are small, only three or four inches long, and very pale. And very pale-coloured crayfish also live there. Animals and plants living without the sunlight usually have very little colour. Have you seen a plant that has sprouted in the dark? The potatoes in the cellar, for instance? The sprouts are very pale, almost white.

Well, it is time for us to turn back. We can wind the string as we go, and on the way we can talk about caves.

HOW CAVES ARE MADE

What makes a cave? It did not just happen. There is always a reason. As I said before, when the rain falls a lot of water runs away in the streams. But much of it sinks into the ground. Some of this water may come out again as springs if there are any openings. Some of it is swallowed by the plants. Of course, they could not live and grow without the water in the ground. The loose soil holds a great deal of water. But some of it sinks below the soil. And there is water even in the hard rock beneath. For if there are cracks in the rocks, or tiny spaces between the rock grains, the water will sink down.

The water in the ground will actually dissolve some of the rock. You already know that. There are many reasons to show this is true. It works very, very slowly. It probably takes thousands of years to dissolve just a little bit of rock. Of course, not all kinds of rock will dissolve in water. But limestone does. You know that now. And most caves are found in limestone. Bit by bit the firm rock is removed as the water seeps down. Soon small openings are formed along the cracks, and these grow wider. In some places, where the rock is dissolved easily, larger cavities are made. After a long time, probably thousands and thousands of years, many large caves will be eaten out, connected by narrow passages.

In some caves the rooms, or galleries as they are sometimes called, are made larger by the rock falling in from the top and sides. If the whole roof falls in a hollow may be formed at the surface of the ground. Indeed, many caves have been found because of such a hollow.

Many people think that underground rivers carve out the caves. But this does not happen very often. Most caves are made as I have said, by the water slowly dissolving the limestone. A few caves have been made partly by rivers, and some have rivers in them now. You remember the two in Mammoth Cave in Kentucky.

There are many more interesting things to be learned about caves, and the life in them. But we do not have the time to talk about them now. Here we are out again on the mountain-side.

CAVES OF THE WORLD

There are many caves in the world. In North America the Carlsbad Caverns are one of the largest and strangest groups of caves. They are away out in the wild lands of New Mexico. Probably the Indians knew about them long ago, but not the white man, until one day, many years ago, a young cowboy by the name of Jim White riding over the desert saw a dark smoke-like column coming out of the side of a mountain. Imagine his great surprise when he found it was a cloud of bats, flying out of the cave, now in small groups, now in great clouds like belching smoke. He took a Mexican boy with him, and went in to explore. As they went in farther and farther, the opening of the cave became a speck of light, then disappeared entirely. They were in complete darkness except for the light from their lantern. They unravelled string as they went. On and on they crept. Fairyland after fairyland appeared. It took many hours to go through. Then they found their way back again, by winding up the string. Now the Government of the United States has made the Carls-

bad Caverns a part of a National Park and everyone who visits this part of New Mexico always goes to see the wonders of this place.

It may be some of you live near caves and have even been in one. Those of you who live in Kentucky know the great Mammoth Cave of which I spoke. It is really not just one cave, but several hundred miles of caves connected by narrow openings. There are small lakes, rivers, and even waterfalls in some of the caves. If you live in Virginia of course you know about the wonderful Luray and Endless caverns in the Shenandoah Valley. And I dare say some of you have been lucky enough to visit them.

There are some caves in Mexico. There are not many in the northern United States or Canada. That is because long ago great fields of ice, or glaciers, came down from the north. They scoured off the mountain-tops and covered the ground with hills of broken rock and sand, and ground-up masses of all sorts of material. And so the rocks of the Earth's crust were deeply buried and protected from being worn away any more. And except in a few cases, men have not been able to discover whether caves were made in the rocks before they were covered up with the ice-made soil.

There are the Cheddar caves in England, many caves in France, and caves in Asia. Indeed, in most countries there are caves.

CHAPTER VIII

THE SEA



The sea never changes and its works,
for all the talk of men, are wrapped in mystery.

Typhoon—JOSEPH CONRAD

LAND AND SEA! The continents and the oceans! Our surprising Earth has these two great things. And they are wrapped around with air. The continents divide the oceans. But all the oceans are joined with one another at some place.

The oceans are much broader than the lands. Indeed, they cover three or four times as much of the Earth's surface as the lands. It has been said that if the lands were cut down to the level of the oceans and all the material dumped in, the water would spread out and cover all to a depth of two miles.

The very deepest places of the ocean are called 'deeps'. The greatest 'deep' yet found is in the Pacific Ocean near the Phillipine Islands. It is about $6\frac{1}{2}$ miles deep. The highest mountain on land is Mount Everest in the Himalaya Mountains in India. It is about $5\frac{1}{2}$ miles high.

How do men find out how deep the ocean is? They cannot go down. At first sailors let out a plumb line. Later it was a steel wire, really a piano wire with a sinker on the end. They dropped it from the deck of the ship. When the sinker struck bottom the line grew slack. Then they read the number of feet on the wire to see how far the sinker went down. Now ocean deeps are measured by sound waves, something like radio waves. The waves travel from an instrument on the ship to the ocean floor and back. The instrument tells how far they have travelled. The number is divided by two, one for going and one for coming back. And that tells how deep the ocean is.

FOOTPRINTS OF THE SEA

Now here is a question, a big question—Which came first, the land or the sea? It is hard to tell because it all happened so long ago, long before there were people here to see.

Have you read *Robinson Crusoe*? When he was alone on the desert island he saw a footprint in the sand, and said to himself, "There is somebody else here." For there could not be a footprint if there was not somebody there to make it. It was not a dog's footprint, nor a bird's footprint. It was a man's footprint. Now the sea leaves footprints or something like them. We can find its footprints on the land. Limestone and

sandstone and shale, and the sea-shells in the rocks, and even ripple-marks are footprints of the sea, all of which we find on the continents.

What is limestone? The crust on the bottom of your tea-kettle is limestone. How did it get into your kettle? It was in the water. That is what makes the water 'hard'. It is not easy to wash your hands in hard water because the soap does not dissolve in it very well. Fresh rain-water has no lime in it. It is 'soft'. It even tastes different from the hard water.

Just so, the limestone comes from the ocean water. But where did the ocean water get it? Turn back to the Twins-that-are-Everywhere. You remember about that boulder on the hillside, in the Laurentian mountains in Canada? The pebbly, flaky bits broke up into smaller bits because part of it disappeared just like salt in water. Some of that which disappeared was lime. The streams then carried the lime to the sea with the water. So the ocean gets lime in the water from the rocks. In time there is so much lime in the water that it cannot hold any more. Then the lime just drops down as limestone. So the great ocean tea-kettle all over the world has left the limestones of the Earth. Some people think that bacteria, minute organisms, make the water drop the lime. At any rate, that is why limestone is a footprint of the ocean.

Of course, the sea-shells help to make limestone too. In the first place the tiny animals within the shells got the lime to make their shells from the ocean water. When they died the shells dropped to the ocean floor with the limestone.

But here is a very strange thing. Some of the very

oldest rocks that have been found in the world are limestones, the footprints of the sea. So that looks as though the sea came first. It is a great puzzle.

How can we tell which rocks are the oldest? Men who study them can really tell. The lowest rock is usually the oldest. It was there first. Once I was walking up a country road. I turned to the right and walked over a little hill. Down on the other side was a low ledge of limestone rock. It was in layers, one upon the other. And right across the layers cut a narrow band of rock of the kind that once was melted. Now which was the older, the limestone or the melted rock? A long time ago there must have been a crack in the limestone. The melted rock poured into the crack and cooled to make hard rock. So the limestone must have been there first. So it is the older. It is just like reading in a book isn't it? Only the words are different.

Now come back to the oldest rocks we know on our Earth. They are limestones, sandstones and shales, the footprints of the sea. They are cut through by rock that has been melted. So the footprint rocks are the older.

But there must have been still older rocks to make the limestone. Men have not seen them yet but they know they are there. So we really do not know which is the older, the land or the sea. But at least we have learned why we do not know. Men will find the answer some day. That will be something for you to work on when you are older.

WE WALK BENEATH THE SEA

What is the bottom of the ocean like? We have wondered about it, and so have many other people. No-

body has really ever seen the bottom of the ocean, except divers near the shores. I wonder if you who live inland know about divers? They are men that put on a suit proof against water, and are let down from ships in the shallow part of the ocean just a few hundreds of feet or more. The ocean is deeper than that, much deeper, and men know a great deal about the bottom of the sea, even if they have not seen it.

Let us pretend to walk out on the ocean floor in our seven-league boots. We'll go out from North America into the Atlantic Ocean and see what there is. The ocean bottom is not the same all over so we will walk out in more than one place.

FROM BAFFIN ISLAND TO GREENLAND

Suppose we go away north first to Baffin Island and try to cross to Greenland. The shores are rather high and rugged on Baffin Island, not really mountains, but rocky. The cliffs are pretty high in some places. It is steep going at first, but as we get out a bit under the water the sea-bottom is more level. Much sand and mud have been carried out there. There are a few scraggy seaweeds in the mud. Not many and they are very small. The water is really too cold for most plants. They do not like it any more than we do. Here we are on the edge of a very steep slope, almost a cliff! Right in front is a great drop in the bottom of the ocean. This is not very far out either. Indeed, there is only a narrow channel of water between Baffin Island and Greenland. But we must get across this deep place somehow!

So, I guess the only thing for us to do is to go down. We almost seem to be dropping, ever so far. It must be about three miles down. There is a lot of soft mud here,

but very few shells. Those we see are very small, as small as snowflakes, and pointed and starred like them. Pretty stiff going, isn't it? Just look at this steep slope, like a high wall of rock in front of us. We have to get up the wall if we are ever going to get to Greenland. If we could get down we can surely get up. So, up we go! And here we are on top.

But we are still some distance from Greenland. On we go. It isn't so hard walking. Now we seem to be walking up-slope. The water is much shallower here, and it is becoming brighter. And here we are on Greenland. Isn't it cold? See that big iceberg out there? There is an ice-cap all across Greenland, except around the shores. I think we shall not stay here very long.

That was interesting! Let us take another walk, but farther down the coast this time. Suppose we start from Nova Scotia.

FROM NOVA SCOTIA TO EUROPE

Look at your map so you know where we are. The coast is rather low here so we walk out gradually under the sea. There are level stretches of sand. It is pretty easy walking, but we have a long way to go. Here are fish, such numbers of them! This must be the Banks of Newfoundland where men come to fish from all over the Atlantic. But we must push the fish aside and go on over the Banks. There are seaweeds here, much larger ones than we saw farther north. The water is still pretty cold though. And the Banks are a bit uneven in spots.

What is this mud we are in? It is very sticky. And here is a steep slope again, almost a cliff! Watch out! Don't drop over the edge. For the ocean gets very

deep here, nearly as deep as the mountains are high. This must be one of the ocean deeps. Down we go. Carefully! It isn't really very hard. That is good, for there is still a long way to go. We may see an Atlantic cable. The bottom is a little different here. It is a soft, gooey ooze, made up of millions and millions of the tiniest of shells. Each shell is a cluster of little balls or globes. Men call them 'Globigerina' (globe-bearing), and they call the soft mud 'Globigerina Ooze'. The white cliffs of Dover are made of this Globigerina ooze dried out. We call it chalk in school.

It is getting deeper and darker. Now the bottom seems to be all red clay, hardly anything else. There are a few little bright quartz-like pieces, like the snowflake shells. It is very heavy walking, and bits of the red clay stick to our boots. Miles and miles we go. On and on! It is good that we are not in a big hurry.

I do believe we are beginning to come up a little. It is not quite so pitch black. The bottom has changed again. It is no longer the red clay but the gooey Globigerina ooze again. We must be nearing the other side, and Europe.

Ah! Here is the rocky wall-like slope on the other side of the Atlantic, guarding Europe. Up we go! The rock edges are very jagged. There is green mud here and it has shiny bits of rock in it. Oh! this mud must have come from volcanoes. There may have been great volcanoes beneath the sea here at one time. Or maybe the ashes from a great volcanic explosion on land fell on the ocean and sank to the bottom.

It is lighter now. And there are some corals and sea plants. The water is much warmer here. The shells are

big, and they have such pretty colours. I wonder why? Of course, it is because the Gulf Stream crosses here and this coast is warmer than the other side of the Atlantic from where we started. The ocean bottom seems to be rising, and it is getting brighter and brighter. The water above is very rough. We must have come up in the Bay of Biscay. The water is usually pretty rough here. There are lots of seaweeds of many kinds, and shells, and it is not very easy walking.

Well, here we are in France! I hope you speak French for I am hungry!

FROM NORTH CAROLINA TO AFRICA

Let us try again. This time still farther south — from Cape Hatteras in North Carolina. Before we set out, look at your map again. We hope you have not put it away. Do you remember when we were talking about Plains we spoke of the great coastal plain that stretches from the Appalachians far out under the sea? Well, this is it, or at least a part of it.

Now we are walking on and on. Very level ground, isn't it? The water is shallow too, and there is sand and mud. The sea-plain stretches evenly far out. The water is very muddy. Probably there is a storm up above. There often is in this part of the Atlantic. There seems to be a quantity of seaweed here. Don't get tangled in it. This water is a little warmer than it was up north, but it is still pretty cold. The sea plants get covered by all this drifting sand and mud. Here is a steep drop. The floor of the ocean has gone down again.

When we get down it will be just like the walk we had across the great deep farther north. There will be volcanic ash and mud, gooey Globigerina ooze and red

clay, and then the rock wall on the other side of the ocean. Only this time the wall will be in front of Africa.

FROM YUCATAN

Let us take just one more walk. This time from Yucatan away at the southern part of the Gulf of Mexico.

We really have not walked out far yet, but here is a great deep again. It is deeper than the Rocky Mountains are high. Let us go down quickly. It is very dark here. Why, there is another steep up-slope, so soon! Let us climb or float up it. For, if we can walk under the sea remember we can float up. Up and up we go! Here is the upper edge, like a shelf. It is just like crossing between Baffin Island and Greenland. Exactly, except that it was deeper there.

Now we seem to be going up a mountain-side under the water. I think we had better pick up a piece of that loose rock to look at when we are up above the water again.

Yes, the bottom of the ocean is sloping up. It is becoming brighter as we get nearer the surface again. But the walking is very rough. These prong-like things sticking out along here are fine to hold on to, but they scratch our hands and feet. I wonder where we are? There is daylight above us. It is one of the islands of the West Indies that we have reached. And there to the north is Cuba, and on the south Jamaica. So this must be Haiti we are climbing up. That deep place must be what men call Bartlett Trough. This shallow water is warm. I suppose because it is so far south.

Do you remember the prongs that scratched us so? They are coral, and are living along the sides of the

island. Let us look at the piece of rock we picked up. Why, it is volcanic rock! Then the mountain-side is part of an old volcano beneath the sea. And this island is really the top of that old volcano. It is a volcanic island. There is quite a high mountain over there to the north. That must be Mount Tina in San Domingo.

If we stay in comfort on this island we will not learn about the bottom of the ocean. We shall have to come back by boat some time and visit the island itself. We have not time now. We must cross the island and go down on the other side. It is a long way across. Now we begin to go down. We haven't much shallow water this time. Here is another deep already! Down we go! This is very deep. This must be what is called the Nares Deep. And how far down it does go! About six miles! Even Mount Everest is not six miles high. So this is something to see.

Here is the wall-like slope on the other side of the deep. This was not quite so wide as some of the other deeps. Up we go. Here we are again on another island. But we still must go on, if we are to find what else there is under the sea. Down again! What, another deep! It takes a long time and patience, because there are so many deep channels throughout the West Indies, and so many volcanoes with corals living on their sides.

But do not these deep channels and high blocks of islands remind you of something? Of course they do. On page 32 I told you about the plateaux in Oregon, Nevada, and California. How in some places great blocks of rock fell and pushed up other blocks between them, forming plateaux and mountains. Just so were formed these channels and islands. The pushed-up

blocks have made the islands and they have volcanoes and corals on them. The blocks that dropped down made the deeps that we have had to cross.

But while we have been talking we have passed the volcanic island. The ocean is getting deeper and deeper. Here again we come to a great steep cliff-like slope down. The bottom of the sea drops suddenly. We will go down again to be sure we do not miss anything. It is just the same kind of Globigerina ooze and red clay that we saw farther north.

But it is getting darker and darker down here. We do not want to turn back because this journey is different from any of the others. We have come a long way across this ocean floor, a long way even for our seven-league boots. Can you feel now, as you walk, that we are climbing upward a little, again? Yes, we are. It is becoming a little less dark. But this cannot be the opposite coast! We have not come far enough! Up and up we go, climbing a mountain range standing on the floor of the mid-ocean and completely covered by the water, even to its highest peak. It lies between Africa and South America. If we could follow it south we should find that it sweeps around in broad curves just as do the coasts of the two continents. We are at the northern part of it. For it does not continue far into the North Atlantic. See, or feel rather, we have passed the top of the ridge and are going down the other side again, in the deep ocean. We still have to climb the other shore of—what continent? What lies directly east of Yucatan?

THE SHELF ALONG OUR CONTINENT

Now let us think a bit about what we have seen under the ocean. We have walked out from the coast of North America into the Atlantic ocean in four places. At every place, some distance out, we found a sudden drop, almost a cliff. From Baffin Island to the West Indies the bottom of the sea slopes steeply to great depths. How strange this seems! Why is it? This great undersea cliff extends right down past South America, though the drop is not so steep there.

This cliff is really the edge of our continent, which extends out under the sea. The ocean has spilled over the edge of the continent. This part is like a shelf, and is called the Continental Shelf. The water is shallow here. You remember that in our walks the cliff is where the continent ends and the deep ocean begins.

Each continent has a continental shelf like this. In some places the shelf is only a few miles wide, but in others it is sixty to eighty miles wide. Indeed, so much of the northern part of Australia has been drowned by the sea that there is almost more shelf than continent.

HEAVY ROCKS UNDER THE OCEAN DEEPS

Now we know that there are very heavy rocks under the ocean deeps, much heavier than any on land. Why do we think so? Well, it is a bit difficult to understand, but let us try.

Hold a piece of wool in one hand, just one end of it. Have someone strike the other end. You do not feel it, do you? Hold a wooden stick. You will feel it when the other end is struck. Now try a steel rod. When it is struck at the other end, the whole inside of your hand will tingle with the vibration. The knock does not travel

along the light, soft wool. It travels a little along the heavier, firmer wood. But it travels very fast along the heavy, dense steel, almost like lightning.

So it is with the Earth. Men find that the vibrations of earthquakes are carried strongly and quickly by the rocks beneath the oceans.

LIFE BEGAN IN THE SEA

There is another very remarkable thing about the ocean. Life began there and not on the land. How do we know? Let me tell you.

But first, what do we mean when we say that a thing is alive? Are stones alive? "Of course not," you say, "but trees are." What is the difference? Do stones eat? Do they grow? Do trees eat, and do they grow? Plant a stone in your garden. Will it ever grow up and have seeds that grow into other little stones? "Indeed not." Plant a tree in the garden. Will it grow, and have seeds, and produce more trees? You know the answer.

Stones do not grow. They do not eat. They do not produce more little stones, except by breaking. But trees do eat and drink. They grow and produce other little trees of the same kind. They are alive!

There are two great divisions of life, animal life and plant life. Right now the very lowest kinds of plant life live in the sea. Men call these lowly plants—algae. And another interesting thing is that the very lowest kinds of animals also live in the sea. These are tiny bits of things that you can hardly see.

Now where do the highest forms of plant life live, on land or in the water? The flowering plants with carefully covered seeds are the highest, and they live on land. And the very highest form of animal life! What

is it? Why, Man! You and I! Man lives on land. He could not live in the water. He could not breathe. But even if we leave man out, the very highest forms of other animals live on land. You know that—animals like bears, wolves, elephants, apes, and many other kinds.

Life began in the sea. It grew and spread. It changed and higher forms appeared. Then some plants and animals came up to the shores and learned to breathe air. In time some did not go back to the sea. That was the beginning of land plants and land animals. Much of this long story of changing habits and changing life is written upon the footprints of the sea—the limestones, and sandstones and shales.

And we can read it.

Think of sheets of paper, a long composition which you have written for school. There are four pages. Each page as it is written is laid upon the one written before it, not piled neatly but shoved over a bit because you accidentally drew your sleeve across them. Page Four, the last you have written, is lying on top, the only one completely uncovered. It is pushed over, and part of Page Three shows from beneath it. Part of Page Two is covered by Page Three but not all of it. A piece of Page One is showing beneath Page Two.

Now the rocks, too, are piled up like this, one layer upon another. They are pages of a composition in another way. Each layer of rock is a page upon which is printed the story. The words are the rocks themselves and within them the seaweeds and sea-shells now turned to stone. It is a thrilling story, but you have to pay great attention to read and understand it.

What do we find on these stone pages? On the last page not quite all the shells and plants are like those that live now, but many of them are. The leaves of the trees look exactly like those living now.

But look at Page Three which peeps from beneath Page Four. Only a few of the plants and animals are like those that live now. The plants and even the animals were more simple.

Look beneath Page Three at Page Two. At the end of Page Two there are very few land animals at all. At the beginning of Page Two not a plant or animal on land! There were only simple seaweeds and shells at the time it was written. Some of the sea creatures did not even have brains enough to move around to get their food. They could only get what the currents of water brought to them.

And the very old limestones at the beginning of Page One, do not tell us anything about life. Perhaps there was no life. Or, perhaps all signs of life were burned out when the melted rock burst through the limestone.

But we must be sure to read the story aright.

Mr. Smith finds dark shaly rock with a little oil in it which burns. He says "Oh, I have found coal!" But has he? Let us see. We must examine this rock very carefully. What sort of footprints are in it? There are shells in it. Let us look at the four pages of our rock book. Compare the shells with those in the shale. These shells in Mr. Smith's dark oily shales are like the shells at the very beginning of Page Two. But the great ferns that formed coal lived much later, at the end of Page Two. So there is no coal in the shale. The plants that made coal had not yet appeared on the Earth when the

oily shale rock was made. The little oil in the shale probably came from decayed seaweed, early shell animals or even from primitive fish.

This and many other things we can read from the pages of the Earth.

THE INTERLUDE

THE EARTH BEGAN



The root is sharp: it cuts the soil
In easy growth and with no toil.
The eye is sharp: it pierces air
And reaches stars, unaided, bare.
One knife there is that's sharper still
For mind cuts Time itself at will.

(Source not known)

THIS IS SOMETHING DIFFERENT!

We have talked about what is happening to our Earth now. You see for yourself how it is changing.

But how did our Earth begin? No one was there. But many men have thought about it, down through the ages.

THOUGHTS MOUNT ON STEPS

Simple First Steps

How to get food, how to be safe from wild animals filled the thought of the first men. Later, Man learned to grow food, to make weapons. Then, when he could store a little food, could feel somewhat safe, he began to think of other things.

In time he began to think of the Earth on which he lived, simple thoughts at first: "We did not make the Earth so it must have been God." Again, in time, some men began to ask one another, "*How* was the Earth made?"

Trying to find out how the Earth was made was like chopping a flight of steps out of the mountain-side. Each man's thought was a step upward.

Another Step

Once it was thought that the Earth was flat. It looks flat. Then came a man who said it must be round. He knew why he thought so. That is another story. We know now that he was right.

Standing upon this new truth—that the Earth is round—another man chopped out a higher step—the Earth moves around the sun, not the sun around the Earth.

And so, higher and higher steps were carved out slowly and with great thought. Each upward climb gave a wider view of the whole question, just as steps on the mountain-side give a wider view of the whole valley below.

These men have belonged and do belong to many

countries. We cannot name them all here. There are too many.

A Higher Step

Long ago, in the east in Persia, wise men studied the stars. They found the stars are ruled by laws, not just whirling around any old way. New stars were born. The Earth is a star, a star that moves around the sun. After many years the thought grew that the birth of the Earth was like the birth of a star.

Yet Another Step

An Englishman, named Newton, watched an apple fall to the ground. Why did it fall down, not up? Because the Earth is bigger than the apple and pulls it. Everything pulls everything else, and the heaviest wins. The law that makes the apple fall to the ground keeps the planets moving around their sun. That was Newton's step.

Higher Still

A Frenchman, named Laplace, stood upon Newton's step and chopped out another step. Laplace thought two stars crashed together and exploded, as they would, leaving a disc-like mass of whirling gas. As the gas whirled, bits of it broke from the edges, forming other centres of whirling gas. In time all cooled, more or less, and became solid. Thus, he thought the sun and the planets, the stars that move around it, were formed. One of them, one of the smallest, was our Earth.

This seemed reasonable at the time Laplace lived. But in the years that followed other new truths had been discovered. The planets around our sun are not moving in the form of a disc, but in a spiral, and they

do not all whirl in the same direction. One of the moons around Saturn whirls differently, and there are other satellites and stars whirling in different directions, or on different orbits, as the 'star men' say.

Onward

Two men in the United States, Moulton and Chamberlin, thought about Laplace's explanation. They stood upon his step and chopped out another. The great original star made up of our sun and the planets that now turn about it, probably sent out great bulges of gas around its rim as our sun does now. Another star, bigger still, shot past it and drew after it balls of gas from one or more of those bulges of sun-matter, drew them right out away from the sun. But the disturbing star sped on far away. Its power to pull grew weak, and the central sun, too, continued to pull back. But by this time, the central sun also was a long distance away. The long banner of gas balls of sun-material curved around the sun, but only the nearer parts fell back into it. The more distant parts still turn around the sun.

Each ball cooled and became solid, drawing to itself all the smaller pieces within its power. Thus, thought Chamberlin and Moulton, the planets were born, and our Earth was one of them.

As all the smaller stars or meteorites within reach crashed into our Earth, it became hot in places even to melting point. So, slowly the heaviest parts sank towards the centre, kneading the Earth's surface like bread.

The main point to remember about this step is the belief that after it first became cool and solid the Earth

still continued to grow, sweeping up all the meteorites in its path.

Upward

But more new truths were learned. Some of them are hard to understand.

When the trembling of the earthquakes was measured it was found that the centre of the Earth is heavier than the outside.

Then, the salt in the sea was calculated. If there had been ocean from the beginning there would be more salt in the sea than there is.

And then the great truth about radium and radium activity was discovered. The rays it gives off, though you cannot see them, make a great heat. Most of the early work on radium was done by a Polish woman, Madame Curie. She lived in Paris, and married a Frenchman. Madame Curie's new truth must be considered, too. Far down in the centre of our new Earth-star the radium made great heat.

Again Another Step

Thinking of these things, two Englishmen, Jeans and Jeffreys, stood upon Madame Curie's step and chopped out another step. They agreed that a passing star drew out sun-matter, but they did not think the Earth became solid soon, but that it was molten for a long time.

One mass of gaseous sun-matter drawn from the sun was our future Earth. Within this mass were areas in which the gases were more condensed—nuclei, centres of heavier gas material. In time some of the gas even cooled to molten matter. All around the whole mass, like an envelope, was a vapour of lighter gases and

steam. Picture it, then, hurtling through space, our future Earth, a great turmoil of electric storms within it, of lightning flashing from gas cloud to gas cloud, and from gas cloud to the largest centre, our Earth-to-be. The sunlight would be far outside. It could not penetrate where the lighter gases and steam circled the whole whirling, flashing, boiling mass, into which fell still other starlets.

Gradually fewer and fewer starlets were left. The seething mass began to cool. Some minerals crystallized here, some there. The heavy ones worked downward into the still molten lighter minerals.

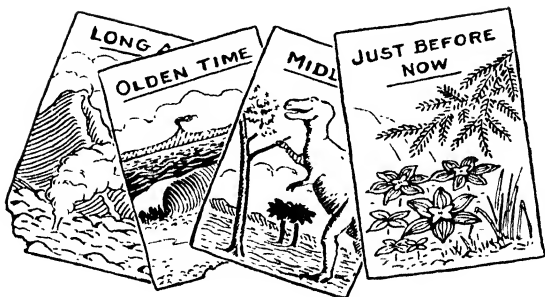
Some heavy minerals sinking in would make a basin here and others there. As the Earth cooled the steam became rain and fell onto it. In time the basins were filled with acid water. But within the Earth's centre there still was great heat from the great weight of the heavy minerals and from radium activity. For a time parts of the Earth's crust would burst forth into lavas, heaving up. Then, in time, that too cooled. The water was no longer steam, but was gathered into the basins and dry land appeared. The sun for the first time could pierce through to the surface of the new Earth.

* * *

Such are some of the thoughts men have had about the birth of our Earth.

PART II
OUR EARTH IN THE PAST
A STORY IN STONE

INTRODUCTION



High up in the North in the land called Svithjod, there stands a rock. It is a hundred miles high and a hundred miles wide. Once every thousand years a little bird comes to this rock to sharpen its beak.

When the rock has thus been worn away, then a single day of eternity will have gone by.

The Story of Mankind—HENDRIK VAN LOON
(Courtesy Liveright Publishing Corporation, New York)

HOW THE STORY IS WRITTEN

AND NOW THE EARTH tells its own story. Men can only think how it may have been born. But it is here. Its story after it was born is written on its own broad surface, the rocks, the mountains, the rivers and valleys and the plains.

There are gaps in the story, words missing. Some of them will be found in due time. You may find one, so that later people may read more clearly. Parts of the story are rubbed out. Parts of it are covered. But some parts of it we can read—a story really and truly written in stone.

THE GREAT RHYTHM

It is the story of a Great Rhythm, great movements of the Earth. For the solid rock crust of the Earth actually moves. It has moved many times in the past. It will move again. The continents rise. Mountains are born. The continents sink. The sea steals in stretching across the land long fingers of water which widen and spread over its surface. The changing rhythm is like some grand organ music, with crashing thundering chords when mighty mountains are born. And then come the softer notes while the waters of the Earth, the winds and ice change its surface. As it does now, so it did then.

The Great Rhythm was repeated and repeated and yet in the repeating it was different each time.

It is true. It is written on the surface of our Earth—land where now there is sea, sea where now there is land, and even sea where now there are mountains. For these seas left their footprints in the rocks they made. We can find them, and use them like words to read the story the sea has written.

LIFE IS CHANGED

But the crashing chords and the softer notes of the Great Rhythm were not all. Quietly, silently, Life too changed. The plants changed. The birds and the beasts

changed. All living things, plant and animal grew from simple to higher things.

Finally Man appeared.

THE FOUR-PAGE COMPOSITION

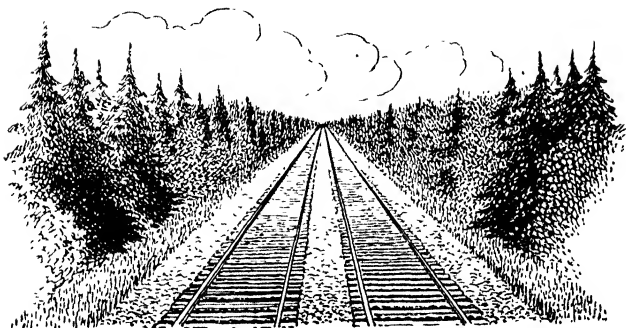
There are four long, long pages to this composition. Each has its own story of the rhythm of the Earth, each story different. The sea did not always cover all the continents at the same time. Each page tells of new mountains born. Each page has its own story of the change in Life.

It is the four pages of the composition, each page as it was written laid over the one written before it, not piled neatly one on top of another, but spread out, as I said before, just as though your elbow had accidentally pushed the pages over. Only the last page is all uncovered. Parts of the others show beneath one another. Just so, lie the rocks. The oldest writing is at the bottom, partly covered by the next. In the Earth's story, also, only the latest rock words all lie uncovered.

THE STORY

CHAPTER I

LONG AGO—PAGE ONE



In the beginning God created the Heaven and the Earth.
Genesis I, 1

PAGE ONE tells of the time long, long ago, when there was no life on land or sea. Here the Great Rhythm began. This was the strangest time of all, when the great Precambrian Shield of North America was born.

RAILWAY TRACKS

Did you ever stand on a double line of railway tracks? Right where you stand the tracks are far apart. But look ahead, away off near the horizon the tracks seem to run together. You know in your mind they are just as far apart there as they are where you stand. But they do not look it.

It is just the same in time. Think back into yesterday,

a month ago, or a year ago. The things that happened then seem close together now. Of course they were not. When you look back, far back in the Earth's story, the things that happened seem to run together. They did not really. There was time between them—long, long stretches of time. It is like the railway tracks. You have to know in your mind that these things happened, one a long time after the other.

And so the story was written on Page One so long, long ago that, like the tracks, its happenings seem to run together for most of the time. There were two main parts in it, with an immensely long time in between. Each part had many happenings.

WE WATCH FROM A MOUNTAIN

Let us stand high up on a mountain top somewhere in the Adirondacks of New York, or in the Great Canadian Shield, for these are some of the oldest parts of the Earth.

Around us here where we stand are high mountains. Yes, there were high mountains here in the centre of the continent.

GREAT CHORDS OF RHYTHM

Aged Mountains

Mighty movements of our Earth made these mountains long, long ago. The rocks were shoved, twisted, turned over, or floated on the white-hot molten rock which welled up from below and burst out upon the surface. For look! There are volcanoes! Great active volcanoes, as far as we can see, belching out fire and steam and ashes! Lava streams boil over the volcano craters, or ooze from huge cracks in the mountain-

sides. The bright hot lava flows down swiftly. It changes to a glowing red, and then grows dark, but on it rolls, becoming thicker and thicker and it flows more and more slowly. It fills up the valleys. A wall of hot, dark lava pushes across the rivers and plunges hissing into the sea. Thick clouds of steam curl up from the hot lava.

Lava Pillows

How do we know this happened, here in the middle of the continent? How do we know there were rivers, lakes and oceans? Because some of the lava in these old rocks has cooled in water.

Pour some boiling toffee into water. It forms in 'blebs'. Well, there are 'blebs' or 'pillows' of lava in these ancient rocks. So we know there must have been water in which the lava cooled quickly.

Gold in the Rocks

Up in Northern Ontario, there is gold in these rocks, that were melted once but are hard and firm now. These gold-bearing rocks lie across Northern Quebec, Ontario and Manitoba. They have brought vast wealth to Canada. Canada is the second or third most important gold-mining country in the world. South Africa always is first in the amount produced. In some years Canada is the second, in some years the United States.

Radium

Far out on the northwest of the Canadian Shield, near Great Bear Lake, is some of this ancient rock. It is a very heavy dense kind of rock, black as tar, pitchblende, or uranium. It, too, was once molten rock, and cut or melted its way from beneath, right through older

rocks. In this black rock is a very precious thing—radium. Men found it here just a few years ago.

It was a very important discovery to the whole world, because radium is used in hospitals in helping to cure some kinds of illness. Before this discovery radium was scarce indeed, and very expensive. Only wealthy hospitals could afford it. There was only one place in the world where enough of it could be mined. That is away off in the Belgian Congo, in Africa. Look at your map again! Now that radium has been found near Great Bear Lake there is more of it and it is cheaper. Even the smallest hospitals can have it now.

And still more recently from that uranium comes the power that made possible the atomic bomb, an energy that has possibilities greater than annihilation—making into nothing—an energy that can open a door into the future, to build civilization, not break it.

SOFTER NOTES

The Rhythm Changed

Again listen! Rushing water! A river hurrying headlong to the sea! There, where its bed is steep, it runs swiftly and tears off some of its banks. It rolls the pieces slowly along its channel, scouring its bed deeper. Farther on, it is slow and sluggish again. It is undermining its banks, dissolving out mineral salts, and making caves. The banks will fall in when the caves beneath become larger.

That will take a long time, you think. Oh, yes! A very long time. Thousands and thousands of years.

But see, the river farther down has worn a very wide valley. So the river was working here, long ago, leveling the high continent, just as rivers are doing now.

Oceans Then, Too

And the oceans, wherever they were then, were tearing away their shores, breaking down, grinding up, and dissolving the rock.

And so the winds and storms, the rivers and oceans wore off the top layers of rock. It took ages of time. One thousand feet worn off! Two thousand feet! The top surface became lower and lower. Now many thousands of feet are gone. How many we do not know. There is no way to measure it.

And there, we have a worn-down plain. Its planed-off rocks show how twisted and contorted they were, shoved this way and that long before.

A Desert!

The plain is a desert. We stand now on great wide desert land. No birds! Wind? Yes, but not in trees. There are no trees! No voice! No call! No buzzing of insects! What can the sounds be?

Listen! There is a storm, with lightning, rain and wind! See the clay and sand blowing on and on. The rain catches some of the sand and packs it down into the hollows. You can hear the echoes of crashing thunder and wind.

Over there are some high rocky hills, standing up from the desert plain. What odd shapes they have, full of hollows and sharp-edged rocks! No wonder there are echoes! Why are there high rocks over there and none here? Because those rocks are stronger than their neighbours. They have withstood the storms longer, though the wind has blasted them with sand.

Listen to the wind! For miles and miles it sweeps

over the earth, wearing down the rocks, sorting out the sand and clay.

The rains dissolve some of the mineral salts in the rock, washing some of it to the rivers, and to the sea.

Just the same then as now!

A LINE WHERE THERE IS NOTHING

And so the mountains are gone, worn away. Only their roots are left. Right on top of these mountain roots lie younger rocks, many thousands of feet of them. And there, where they join, is only an irregular line. The mountains that had been built up by the great chords, the hissing lavas and wild shaking of the Earth, these mountains were worn down, cut off by rain, wind and frost. There is nothing there, only the irregular line where the roots of the mountains are overlain by later rocks.

ABOVE THE LINE

On the East

And from where did these younger rocks come?

Along the eastern part of North America, where the Appalachian Mountains now stand was a long trough of the sea. For the Appalachians were not yet born. And into that trough the rivers on either side carried sand and mud from their shores, and deposited lime. And out of this some of the younger rocks were formed, in the floor of that inlet of the sea.

An Inland Sea

And in the centre of the continent are sea-laid rocks. There was a sea there, something like Hudson Bay, but larger. It lay all around Lake Superior and south into Michigan. This sea, too, laid down rocks on its floor.

In these rocks is iron, great beds of iron ore. In Minnesota, Wisconsin and Michigan, men mine for iron in these rocks laid so long ago.

A Strange New Rhythm

Something else is written on this Page One, in Ontario. It was cold, very cold! Hard to believe, is it not, that men can tell what the weather was like so many millions of years ago? But you can read it for yourself. For here are rocks filled with boulders, ice-scratched boulders. It was so cold there were icebergs in this inland sea. Where the boulder-bearing ice came from we do not know. It may have come from land in the far north. Or, it may have come from ice-filled valleys near by. So much of the writing of this page is hidden by later rocks that it is difficult to tell. But this is the very first ice that we know about.

GREAT CHORDS AGAIN

And once this happened. A huge mass of molten rock was slowly moving up toward the surface of the Earth. Wherever it found a crack it pushed in. It was hot, terribly hot. It was so hot that it melted some of the more ancient rock above it. This made more molten rock. It spread far and wide. When it found a weak layer it pushed in. It pushed up and up, sometimes along between two layers of rock, sometimes right through a whole group of layers. It cut through or covered all that now lies beneath it. As it slowly melted its way upward or spread in sheets between the rocks it 'bowed up' the Earth's surface. As it rose higher it cooled and slowly hardened into crystals.

This Rock Gives Us Copper

Many metals and precious minerals are often found in these slowly cooled rocks. And in the rocks on this page we find a great belt of copper-bearing rocks. These are the rocks of the Michigan copper mines. We will talk about them later when we learn about copper.

And Nickel

North of Lake Superior, around Sudbury, Ontario, are the greatest nickel mines of the world. Men think that the heavy dark rock in which the nickel is found was thrust up from below at this time.

And Silver

And still farther east in Northern Ontario, these long tongues of melted rock pushing between other layers and eating their way through cracks, widening them by melting the sides, bore with them the precious silver of the Cobalt region.

And all these riches of copper, nickel and silver, and many other precious minerals and metals that men find now, were thrust up from far below millions of years ago.

AN OLD SHIELD

Did you ever see a picture of an old shield, the kind that the knights used in the Crusades? They used them to protect themselves. They were made strong to withstand the lances and spears thrown or thrust by the enemy. The central part, or boss of the shield, was curved outward to cover the important part of the knight's body, as he held it in front of him.

In North America these old rocks of Page One form a 'boss' across the northern part. It covers the continent

from Labrador across Northern Quebec and Northern Ontario to Lake Winnipeg, swinging north and west to Great Bear Lake. On the south it crosses into Michigan, Wisconsin and Minnesota. The Adirondacks, too, belong to it, though they are separate from the main part. This great area of old rocks is 'bowed up' like an old shield. Like a shield too, it is very strong. It has kept the continent steady when mighty forces on either side were heaving up mountains. Men call this great stretch of old strong rocks the 'Canadian Shield'. The rocks in the Canadian Shield belong to both the lower and upper part of Page One.

Other continents have their shields too. There is one in South America, in Europe, in Asia, and in Australia. But none of them is as large as our shield in North America. And most of them have their surfaces covered by later rocks, so we cannot read their whole story.

Men think these strong old rocks are beneath the surface everywhere. If we could only dig down deep enough we would come to them.

Why do they think so? Because in places where ancient mountains have been worn to plains the core beneath is always these same old rocks. In the Grand Canyon of the Colorado, and in some other canyons, the river has cut down through thousands and thousands of feet of younger sea-laid rocks. And there, right at the bottom, lie these strong old rocks! In some places men have drilled wells deep down into the Earth. And behold! The same old rocks again!

It is on the surface of the Earth in places now, but it was not always there. All through those millions and millions of years the winds and waves and rivers were

wearing off the rock that lay above it, thousands of feet of rock. For when this rock was molten the surface of the continent was high above it. But gradually the rock above was worn away and the melted rock below, hardened now, became the surface.

What a Land!

Here at the end of Page One we see this boss which covers the northern part of North America was dry land for millions and millions of years, as it was earlier on Page One. It was a low land by this time, worn down. And what a land! Still no trees! Still no animals! Still, desert, wind and water. Winds rushing over a vast country. Water flowing swiftly or slowly to the ocean. A wild, wild land! Thundering storms sometimes! Bright sunshine sometimes! Darkness and daylight! The sun rising in gold or in a lowering red, passing across the sky, and setting in glory or in storm. One day, two days, a year! One year, ten years, a hundred years, a million years, many million years! Still, a wild land!

ON THE WEST

Lane-way of the Sea

And during most of this time on the west of the continent a deep ocean lane lay from north to south where the Rocky Mountains now stand.

And see the high land on both sides of it! Rain, and storms, and rivers are levelling those highlands, just as they always do. The sea-lane lies here for many long years. Boulders are broken from the rocky lands and ground up to smaller pieces. Some of them are slowly dissolved. The sand and mud were carried down in that time, millions and millions of years ago, just as

they are now. And they were all carried out and dumped into this great sea-lane, or dissolved in its water.

And the waters of the sea-lane laid beds of limestone upon the sand and mud from the worn-down highlands. Great thicknesses of rock were formed in the trough of the sea-lane, a thousand feet, two thousand, thirty thousand, sixty thousand feet!

Such an amount of rock!

This rock can be measured so we know it is thick. It is still there. But it is no longer in a trough. In Montana, Idaho and British Columbia it is a part of the mountain ranges. For, along with the rocks of Middle Time, you will learn later, they were pushed up when the Rocky Mountains were born. Farther south in Arizona, as I said before, these old rocks are covered by many feet of later rock. And there the mighty Colorado River has cut down through them all. Some of them are laid bare in the walls of the Grand Canyon.

LIFE AT SEA

Any Plants?

Was there seaweed in these sea-lanes on the west and on the east? There certainly were no plants on the wild desert land between them. There are some queer marks on the sea-laid rocks. They do not look like anything much, but still they might be some very simple seaweed.

Any Animals?

Were there any animals? There are other queer marks on some of these rocks which might be sponges. Sponges are very simple animals indeed. Other forms may have lived. It may be that they did not have shells.

They may have been soft like jelly-fish, and may have quite disappeared when they died.

Then there is a lot of carbon in some of the very oldest rocks. All animals, you know, breathe out a carbon gas, and plants use it and give it up when they die. The carbon in the rocks may have been left by great numbers of simple plants and animals which lived and died in this inland sea. The truth is, we do not know for certain whether or not there was any life at that long-ago time.

CHAPTER II

OLDEN TIME—PAGE TWO



There rolls the deep where grew the tree.
Oh, Earth, what changes hast thou seen!
There where the long street roars hath been
The stillness of the central sea.

LORD TENNYSON

SOME OF THE ROCKS of Page Two are covered by Page Three but the uncovered ones tell much of the story of Life in the sea, and the beginning of Life on land. The rocks are very rough and uneven. The words are cut large and deep. At its close there were many crashing chords, with mountains rising. This is when the Appalachians were born. Great things have happened to make this writing.

AGAIN THE GREAT RHYTHM

Again we have the story of the continents rising and sinking.

Listen, the sound of rushing water!

It is the ocean pouring over the sinking land. And on the floor of this inland sea the continent is being covered slowly with new layers of rock.

But again there is a change. The land is rising now. The Earth is heaving. Mountains are piling up. The Earth's crust is tearing open. No wonder the words of Page Two are cut large and deep.

Listen! Again! The sound of rushing water! The inland seas are flowing back to the ocean bed.

Five times our North America sank and the ocean came in. Each time the water covered large parts of the continent, and great thicknesses of sea-laid rock were built up, one layer upon another. The water covered only a small part of the land at first, and then the continent sank, the blue sea crept farther and farther in. Each time the continent rose again from its sea-bath. Five times! Up and down and up the continent slowly went. And then, a sixth time it was depressed, but only a little, so that the shores were flooded.

WHERE WAS THE LAND?

WHERE WAS THE SEA?

At first the great central part of the continent was land, with the winds, waves, rivers and storms wearing off its surface. Still no animals and no plants on the land! Still a wild, lifeless, desert land!

But in the low-lying parts along the eastern coast, in the great trough where now stand the Appalachians, and in the west where now the Rocky Mountains stand, lay quiet shallow seas. At the bottom grew thick strong weeds. They have left large twisted masses in the muddy rocks which were then the sea-floor. These large masses were made up of the simplest of weeds, just

stems growing on muddy bottoms and waving in the water. And among the weeds were a few lowly forms of animal life.

But it is written on this page that the later invading seas flooded over vast areas of the interior of the continent, especially during the second and fourth invasions. The fifth time the sea was not so broad. After this fifth invasion, so say the stone words, the great continents of the world were mostly dry land as they are to-day. Nearly all the sea had left North America. Then, as now, the rivers, winds and frosts were wearing down the high places and filling in the low places. They were changing the whole surface of the continent. The sixth time a little of the sea flooded over the western United States and western Canada. It was really very little compared to what there was during most of the time of Page Two.

What the Seaweeds Grew To Be

The simple seaweeds grew more definite—clumps of weeds about 12 inches high, growing from a centre, spreading out, moving gently with the water. Side by side they stood, over miles and miles of the flat sea-floor. Many of them were destroyed in stormy weather. But some were left. They were slowly covered with the mud or the deposited limestone and there we find them, in the rock, to-day.

And then, in time, some spores fell near shore and learned to grow partly in the water and partly on land.

By the time of the fourth invasion of the sea, as it is written on this Page, large fern-like plants began to appear on parts of the land that were uncovered. They grew and spread, wherever they had a chance.

Coal is Made

And when all the continents were rising from the fifth sea-bath written on this Page, there were wide swamp lands. The ferns and other swamp plants were tall like trees, and grew jungle-thick. Broken by storms they floated around and sank. Some grew old and fell where they had been growing. Others grew on top of them, just as they do in the tropical jungles now. They were often covered up by mud brought in by slow-flowing rivers. They lay there for millions of years. What happened to them, buried so deep? A strange thing. They slowly changed into the coal that we use to-day.

Yes, indeed, the plants made the coal, without which we would be pretty cold to-day, in some parts of the world. This was the time when the great fern forests of Pennsylvania, Nova Scotia, England and other parts of Europe were tall, living plants, not coal at all. These plants did not have any flowers. Our kinds of trees were not yet born. These were more simple kinds of plants. But they were big like trees, and there were ferns and rushes. And flying among the trees were great insects, dragon-flies. They were far bigger than our dragon-flies to-day, almost as big as little birds. But, like the seaweed, they were much more simple, and they all died after the time of the big swamps.

ANIMAL LIFE

Brachiopods

And then, in these sea-lanes and along the shores lived Brachiopods. I expect most of you have never heard of them. We do not see them now, at least not many of them. They live in the bottom of the sea some

distance out from shore. The living Brachiopods, the great, great, great, many times great-grandchildren of the Brachiopods in these early seas, are small, only about an inch or so long. They are very simple. In the early part of Page Two they were simple, too, like little bumps in the mud. Each Brachiopod has two shells, just as a clam has. But in the clam the two shells are alike. In the Brachiopod they are unlike. We speak of the shells as 'valves'. They really are a little house for the animal which lives safely within. These early Brachiopods could only move their shells a little from side to side.

But each time the seas came in over the continent during the writing of Page Two they brought Brachiopods that had grown more important, more varied, and many more of them.

Of course, all Brachiopods do not have the same kind of shell. Some Brachiopods are big and some are small. They have different markings on the outside. On some shells there are fine lines from the beak at the top to the edge, all around. On some shells there are lines ringed around the beak or around the outer edge. In some shells there are just tiny spines.

The little animal living inside had a breathing apparatus. It grew inside the shell. In the early Brachiopods the breathing 'gills' were very simple and fastened to a point. Then by the time of the later invasions of the sea there were Brachiopods having large breathing 'gills' fastened to rods, and later still the rods became twisted and the much larger 'gills' were fastened to a beautifully twisted rod, coiled like a spring.

The early Brachiopods, I said, could only move their

shells a little from side to side. But in the rocks of middle Olden Time they had grown so that they could open their shells wide when they wanted to take in water for food or air. There are little bubbles of air in the water that sea animals use.

The Nautilus Family Makes Its Mark

Did you ever see a pearly Nautilus? Probably not, because there are very few living now. Very few people have seen them except in museums.

Well, the Nautilus is really very aristocratic because it comes from a family that lived long ago. The living Nautilus has a distant cousin, about a forty-second cousin, called the squid, which lives in the sea to-day. They are both the great, great, great, many times great-grandchildren of the early Nautilus Family. The squid is the more common and the more important now. It changed its shape and its way of living to suit the changing seas, and its brains grew. So it became wiser. It dropped its heavy shell. It is able to move swiftly in the water. It throws out a smoke screen of inky water to confuse its enemies.

But the poor Nautilus has to be very careful of itself. It hides down in the deep seas. It is lovely to look at, but it is not smart. It did not change. So it still looks like its many times great-grandmother, the early Nautilus, who lived with her relations in these very seas, and whose shell can be found in the markings in these rocks.

Now the early Nautilus was a distant ancestor of the Proud Ammonites of whom you will hear later. The Nautilus was a much more simple fellow than the Ammonite and did not put on such airs. He began with just

one little room. When he grew too big for that, out of the lime in the water he laid a floor over the small end of his room and built on an addition in front. Into it he moved. Then he built another and another. But he built a plain floor separating his rooms. Some of the Nautilus family, the ambitious ones, built the rooms curving around one another. But most of them being humble fellows, just built straight along, one room after another in a row.

Trilobites Lived and Died

Of course there were many other animals in the sea. But not a solitary animal living on land yet.

There were trilobites in the sea. Did you ever hear of a living trilobite? No, you did not, because all the trilobites that ever lived have died. Nobody has ever seen a living trilobite. But we find their fossil shells in the rocks, generally broken. Sometimes there is just a head or a tail, or a part of the hard outside shell. We know what they looked like from their shells. Trilobites were very distant cousins of the shrimps. If you live by the sea you know shrimps. Maybe you have eaten shrimp salad.

At first they were simple—for trilobites. But do not forget that the trilobite was not such a low form of life, not even a simple one. Trilobites must have had ancestors still earlier. We do not know those ancestors because we have never found their shells. Perhaps they never had shells, just soft bodies. The earliest ones we find have shells and they trusted to their shells to save them from their enemies.

About the middle of the time of writing Page Two trilobites had grown and spread all over the sea-bottom

along the shores. They seemed to think "What fine fellows we are. Nothing else has such spines!" They lay in the mud at the bottom and ate other small animals. There was plenty of food. Later towards the end of this time they became clumsy, lazy fellows. They had heavy spines here and there, so they could hardly move around to get their food.

"We do not need to worry," they thought.

They grew and grew. They became very greedy, and ate and ate. They grew heavy with eating. Their shells grew heavy and their stomachs bigger. To make room for their fat stomachs they had to give up some of the space for their brains. But they did not care. Had they not shells to save them, and such proud spines!

But finally there was not much food. The trilobites were so heavy and stupid they could not get to better feeding grounds. And so they all died, all the fancy ones. They died for their pride. The little plain ones lived on for a long time, right to the end of Page Two.

Other Animals

There were corals, for instance. Not many at first. At least, we do not find many. But as line upon line was written upon Page Two, and paragraph upon paragraph, the corals, too, grew and spread. Towards the end of Page Two, they even built up great coral reefs.

And there was the Clam Family and all their relations. Pelecypods we call them all. Clams, you know, like the Brachiopods, have two shells. But unlike the Brachiopods, both shells are alike except that one is right and the other is left. The Clam Family, too, and all its relations, was simple at first, but its members grew and spread, wherever there was mud to live in.

For the Clam Family and some of its near relatives like mud—those that shove along the bottom in their slow way. They, too, grew shells of different shapes, and had different lines for ornamentation.

And then there were the coiled shells, Gastropods, we call them. They and their living relatives have only one shell, but it is coiled. The common snail-shell is a great, great, many times great-grandchild. These early ones were responsible for it all. They grew and spread. They grew plain spires, round and round, low spires, fat spires, thin spires. They put on fancy lines, some round and round, some up and down, some oblique, some crossing others, anything that a coiled shell could think of to make itself different and beautiful.

All this and many more lowly animals first appeared on Page Two.

A PAUSE

Right here we must stop a moment! To talk of something else. Do you notice that all the animals of which we have been speaking lack a backbone?

Here and now on the Earth there are two great divisions of animals, those without a backbone, like the snail, the clam, the Nautilus, and those with a backbone, like a cat, a dog, a mouse, a fish, a snake or yourself.

But on the first part of Page Two all animals as well as plants, lived in the sea, and not a single animal had yet developed a backbone. The honour of being the first group to do so belongs to the Fish.

Fish Grew and Grew!

In the lower rocks of Page Two only a few bony plates are found. But during the fourth time the sea came up in Olden Time, fish swam all over the conti-

nent. We know this is true because we find their bones in the rocks. So many bones! And so many kinds of fish! At first they were great clumsy fish with hard bones on the outside. They did not have scales like fish do now. We call these old fish 'armoured fish'. They did not have a coat of steel but they did have a coat of good hard bone to protect them from their enemies. But they all died. Their hard outside did not save them after all. They were heavy fish and could not swim very fast. They were not as smart as their neighbours. So they did not have a chance to live very long.

Then later appeared a few fish quite like what we find in the sea now. Their bones were inside where we now find the bones of any proper fish. They could swim swiftly away from their enemies or after their food.

The most daring fish that swam in the seas were the very peculiar 'lung fish'. They were so smart that they learned to live in the air as well as in the water. They had a sort of bladder they used to rise or sink in the water. They also used it as a lung. Pretty smart for a fish! When it got very dry and the water dried up they just dug into the mud and lived there until the next rain came.

THE APPALACHIANS ARE BORN AND GROW UP!

Such were some of the creatures that lived in these seas that spread over the continents and wrote their story on Page Two.

But then a change came along the Atlantic coast. There was a great pushing and shoving from the heavy rocks beneath the great deeps of the Atlantic. North America began to buckle up on the Eastern Canadian coast and along the New England States. The birth of

the Appalachians! But the Appalachians did not grow to their full size all at once. There were long pauses. Another great outburst of mountain building broke out when the fourth sea of Page Two began to flood the centre of the continent. The rocks piled up, twisted and turned over. Higher and higher they pushed, farther and farther south they spread. Until near the end of Page Two the mighty Appalachians reached high up to the clouds. This must have been a terrific upheaval. A few volcanoes belched out smoke, and ashes and flame, but not a great many. Right here on the stone page are the ashes at the end of Page Two.

It takes mighty forces to heave up even low hills, and these were lofty mountains, much more lofty than they are now.

And all this happened long before the Rocky Mountains or the Andes were born.

THE SOFTER NOTES

At first, each time the continent rose from the flood the land was a desert waste, a whole continent. No animals! No plants! During all those millions and millions of years! For it takes millions of years for a continent to rise and fall.

Then gradually another change came. When the sea slowly flooded North America the fourth time it did not cover all the continent, nor even as much as it had covered before, for there on the eastern part the Appalachians now mounted guard. Then it was that plants began to creep up to the shore. They found the land good. They thrived. One place they grew was in New York State. For there, in those rocks of New York, are ferns, some of them with stems almost as big as trees.

By the time the fifth sea of Page Two came up the Mississippi valley, the Appalachians were higher and the low swampy lands were farther and farther west. This was the time of the great coal forests of Pennsylvania.

ANIMALS TAKE TO THE LAND

And then the animals followed the plants. They now had something to eat on the land.

The Frog's Cousins

Some of the first of land animals were cousins of the frogs. Have you ever watched frogs grow? I hope some of you live in the country near a river, lake, or pond. If you do you probably know about frogs. They live very queer lives. You see them hopping around ponds catching flies to eat, or making long jumps to get away from you.

But earlier in the summer if you look in shallow water you will see tadpoles, great numbers of them. They are strange-looking things, wriggling around in the water, and getting nowhere very fast. They are quite large at the front but are smaller toward the tail. They are only about an inch long or less, and are dark-coloured. Watch them every day.

One day you will see a little swelling back of the middle. Next day it is bigger. The whole tadpole is growing. Later, would you believe it, a frog's leg appears behind on each side! Yes, the whole tadpole is growing larger. Now there are two legs in front, and the head is a frog's head. It is almost a frog, except that it has a tail. Watch! Now the tail is smaller. It has disappeared right into the body. There is the frog

complete! It can swim under the water like a fish. But it can hop on the land and breathe air.

But, from where does the tadpole come? From eggs, a whole mass of them. They may be floating around in quiet water or perhaps are fastened to a bit of water-weed. From where do the eggs come? A frog, not a tadpole, lays them. The eggs hatch into tadpoles. The tadpoles grow into frogs. Then the frogs lay more eggs.

Frogs, then, spend the first part of their lives as tadpoles in water breathing like fish, and the last part breathing like land animals. Most animals that live on the land can live only in the air and not under water. Frogs and all other creatures that live part of their life in water and part on land breathing air are called 'Amphibians'. It sounds a big word, but it is two Greek words joined together — 'amphi' meaning 'both', and 'bios' meaning 'life' or 'living'.

And the writing in these rocks at the end of Page Two shows that the animals which first came to live on land were these cousins of the frogs. There were quite a number of them. Some of them were large, much larger than frogs. Probably as large as a very big dog, only not so high. Some of their skeletons are found in Texas, and some in South America. You can see some of their fossil skeletons in museums. But many of them we know only from their footprints in the rocks.

Where Now the Land and Where the Sea?

Let us look at the top layer of this Page. Was the land as it is now, or was there sea over some of the continents? The stone words on the uppermost rocks of Page Two show the great continents of the world were mostly dry land as they are to-day. Nearly all the sea

had left North America. The rivers and winds were having a grand time wearing down what mountains there were and building up the valleys. They were changing the whole surface of the Earth. There was a little of the sea flooded over the western United States and down from the Arctic into western Canada, but really very little compared to what there was during most of the time of Page Three.

THE STRANGE RHYTHM

Ice, Again!

South America was dry land. But what a land! A large part of South America, almost to the Equator, was covered with ice. How do we know? Because these very top rocks of Page Two are written all over with very thick masses of boulder hills. They are just like the hills in Canada, New York, Scotland, and Russia, and all places where the last ice stood—all unsorted, higgledy-piggledy piles of great and small boulders mixed up with sand and mud.

There is another way to know about the ice. There are great gouges in the rocks beneath the boulder hills. Just as it happened later on Page Four, the ice fields became thicker and thicker, and so heavy that the ice on the edges was crushed out and shoved along. The moving ice broke off rocks, little and big. The rough boulders were frozen in the ice and carried down with it. They scratched great grooves in the rock-floor over which they were pushed. Large rocks gouged out large grooves. Little rocks only made little scratches.

There they are. You can see them in Peru. There are gouges small and narrow. There are gouges wide and

deep. They slope down a hillside. Before the Spaniards conquered Peru the great Indian Inca race lived there. Near these gouges the Incas built a large open theatre for games. There the warriors raced and wrestled to make themselves strong. They used the gouges for slides in their games. So they are worn very smooth. Now little Indian boys slide down them and push down other little Indian boys. And I hope little Indian girls get some of the fun too.

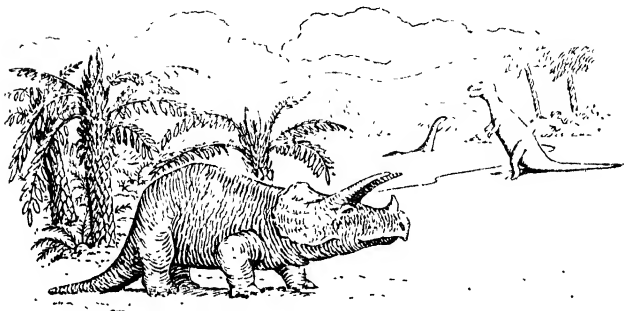
Ice near the Equator! That seems very strange. We think it is always very hot there. But, of course, even to-day it is cold high up in the mountains. But there were not any mountains there at that time. You remember the Andes mountains were born long after this, at the end of Middle Time. Why was it so cold then? Men have tried to answer that question, but no one is really very sure of the true reason, even yet. That may be another study for some of you when you grow up.

I hope you are looking at your map. You need it here.

In Europe there was a great deal of land too. We do not know much about Asia yet. That is another place for study. Not much is known about Africa either. But still it is known that during this time Africa, like South America, was dry land.

CHAPTER III

MIDDLE TIME—PAGE THREE



THE CHANGING RHYTHM

PAGE THREE tells of the growth and spread, and yes, the death of the great reptiles. It, too, closed with thundering chords. For then were born the Rocky Mountains, the Andes and many other mountain ranges.

* * *

For a long time there was a pause! All the continents of the world stood high above the oceans, and were exposed to the wear and tear of wind, rain and ice.

Then, again, in time slowly a change came. For a long time, again, even after the change began, most of North America was high, dry and cold. Not only North America but South America, South Africa and part of Europe. In Europe the north was desert land but to the south a broad sea arm stretched from the south of the present continent to India.

Along the eastern coast of North America the ranges of the new-born mountains were being worn down. Inland, salty lagoons were drying up, and in low spots were trees. For it was no longer all a desert land. Far inland, though, towards the west, high, dry and cold was a desert of sand and mud, now to be seen in the deep cuts of the 'Painted Desert' of Arizona, and the 'Great Red Valley' of the Black Hills. Here for long years the desert reigned supreme. Along the western coast two bays pressed in from the Pacific Ocean, one reaching down from the Arctic and the other stealthily making its way up from California. A ridge of land stood between them.

And then the mountains on the east began to move again, not in narrow ridges and folds as before, but broadly the whole area rose.

On the west, too, the land began to rise again. East of the rising land the two long bays to the north and the south gradually sank further. Just as when you squeeze a rubber ball it swells in places and forms hollows in other places, so the two bays crept together, forming a trough sinking first at the ends and then throughout its length.

At this time, too, the sea covered small parts of England. On its floor were laid rocks—sandstone, shale and limestone—and in them were buried dead sea-shells. In these rocks in England were the first rock-words that men learned to read.

Learning to Read the Rocks

A man named William Smith, a surveyor, was draining swamps and laying out canals in England. He noticed the shells in these rocks, which had been made

so many millions of years before. William Smith collected the curious stone shells. He studied them. He soon found that each rock layer had different shells.

"Why," he thought, "I will look for these rock layers in other places and see if I can tell them by the shells."

He looked. There were the same types of shells. He went farther away. There they were again. The same kinds of rock layers! The same kinds of shells!

That was a great discovery. For from these first few fossil-words men learned to read the rocks, first a little here, then a little there. Soon they could read whole chapters.

THE GREAT CHORDS

In the west of North America this slow upward movement burst into action. Another time of great unrest, of belching volcanoes! The Sierra Nevadas were born in fiery rocks and white-hot lavas, in smoke and steam and ashes!

Not all the melted rock gets to the surface. When lavas burst forth they leave space below, and into that space a great mass of the melted rock slowly wells up from far below. This is the kind of crystalline rock that often holds the precious minerals. And there are minerals in these rocks made at this time. From them came the gold that made the wealth of California many years ago. A great mass of rock like this, that cools before it reaches the surface, men call a 'batholith'. The word is made from two Greek words, 'bathos' meaning 'deep', and 'lithos' meaning 'rock'.

If the rock did not come to the surface, how do we know it welled up and that it held gold? Because, as

before, in the many years that have passed since then, the surface above it was worn off by the rivers carrying sand and mud and everything else into the inland sea. Some of the gold, too, was worn off. It was mixed with the river gravels.

But why did the Sierra Nevadas form here?

Some men think because the upper rocks were weak. They were new. They were laid down where the ocean had invaded the fringes of the continent, in the two bays that came together from the north and from the south. When a great push came from the falling of the heavy floor of the Pacific these weak rocks could not stand it. There may have been other reasons as yet little understood. At any rate they crumpled. When they moved, the hot rock below found cracks and welled up to freedom.

Softer Notes

With the mountains rose a broader strip of the continent. If a bird flew in from the Pacific—if there was a bird—where the narrow trough of the sea had been, it would have seen a narrow strip of mountains bristling with volcanoes, east of that a broad shallow valley, and still farther east the low continent. As the broader strip of land rose the shallow valley to the east bowed down and the sea again came in at the ends. The shallow valley became a trough, a sea-lane, over the low continent.

For many years this sea, the great sea of Middle Time, lay over a vast part of the interior of the continent, while the land to the east and west was worn down. For from the west, and in part, from the east the rivers and storms dumped into the trough the sand

and mud they had worn off the land on either side. They poured into the waters of the sea the lime they had dissolved from the rocks. A long time after the sand, and mud, and lime became sandstone, shale and limestone. These new rocks were not so strong as the rock on the sides. This is always true. The newer sea-laid rock is not so strong as the old land. This was not the first time a sea-lane had come over this part of the continent, you remember. It had happened before, when the rocks were laid on Page Two, and so these new rocks were laid upon older sea-laid rocks.

Maps— Look at your map. See the Sierra Nevadas. Then look at the long line of the Rocky Mountains. And right where those Rocky Mountains now stand was that great sea-lane laying new rock upon its floor.

Crashing Chords, Again

But it did not stay so. Again there came a great push from the Pacific Ocean. Those new rocks were weak. And there and then began the birth of the Rocky Mountains. They began to rise first in the south, crushed up by a mighty force pressing in from the Pacific Ocean. Farther and farther north, and higher and higher the huge ripples of the Earth's crust rose, up and up, particularly on the west of the mountain region. The whole continent rose somewhat, and the great mountain range capped it all, reaching to the clouds.

And when the Earth's crust heaved up into mountains, then as always, the boiling melted rock from below was hurled out in volcanoes, belching out smoke and ashes, flame and white-hot lava. The lava poured from the cup-like craters, and oozed, thick and slow-

moving from slits in the mountain-sides. Not all at once, but through many years it happened, sometimes a great turmoil, sometimes a pause, but ever upward the mountains rose.

And while the Rocky Mountains in North America heaved up, the Andes were born in South America. With wild volcanoes and flowing rivers of lava, in clouds of smoke and steam the Andes were born.

Why did the forces push from the west? Some men think for one reason, some for another. A few men think the whole continent was moving westward and so the western edge crumpled up. Most men, however, think the Earth has been shrinking, throughout the years. The rocks on the sea-floor are heavier, so they sink first. That means when they sink they tear at and thrust against the edge of the continent. Whatever the reason, the great push that folded up the Rocky Mountains came from the west.

LIFE ON LAND AND SEA

"Curiouser and curiouser!" cried Alice.

"With a name like yours, you might be any shape almost."

"They gave it me—for an un-birthday present."

Alice in Wonderland—LEWIS CARROLL

Plants

When plants and animals took to the land how they spread and changed!

Have you seen the Petrified Forest of Arizona? The tree trunks, turned to beautiful stone now, were alive at this time. They did not have the broad green leaves that we see on so many trees now. They were ever-

greens with needle-like leaves. They probably stood high on timbered hills. And somehow or other when dead they were carried down into the valleys and lowlands. But there they all are, helter-skelter, in the weak muddy rocks, that may have been the mud of swampy lagoons. We find ferns, too, and some rushes, but none of the trees that shed their leaves in the autumn and burst out in fresh green in the spring again. When North America was mostly a high dry land a great many things died. Then came the great unrest when the Sierra Nevada Mountains were born. After that for a long time it was warmer. Slowly the forests spread again. This time, with the evergreens were new kinds of trees—trees with flat green leaves, and tree-ferns. There are still tree-ferns in the West Indies. I saw some on Martinique Island. And there were gingkos with their two-part leaves. You remember gingkos still grow in Japan and China, and a few have been brought to North America.

The forests slowly changed along both shores of the great sea that began in the Rocky Mountain trough, and broadened over the centre of the continent. In time many of our own trees appeared: magnolias, fig-trees, plane trees, and shrubs like the laurel and holly. There were still dark evergreens. There were grasses and mosses. And there were flowering plants, for the first time. The wild, barren, naked Earth was clothed, the mountains and hills covered with forest, and decked with flowers, and even the bare plains were softened with grasses.

Think of those grasses and grains. They were food for beast and man. But there was not a man, yet!

Lowly but Beautiful

But the rocks of Middle Time, lying all across the continent where once washed the central sea, are full of the fossil shells and bones of the life of the sea.

There were corals along the coast. At first they were quite different from those that live now. They, too, died during that cold spell. Of course, a few of them still lived in places where it was not so cold. When they came back later to North America, in the warmer part of Middle Time, they were very like our present corals.

What are corals? Have you ever been in a glass-bottomed boat over a coral reef? Corals live in warm shallow sea-water. When one dies the others grow on top of it. So they build up an island.

Most of them have long delicate-looking branches. Delicate-looking! Yes! But trust them not in your bare feet! They are sharp. Look at them closely. They are covered with little holes, pores. Watch them. Out of those pores come tiny waving arms. Hundreds of little waving arms, all over the coral! They are waving the water into the pores. For in the water is food. There are corals in the West Indies, and corals in the Pacific. There are corals in the Mediterranean and in the Indian Ocean, and in practically all warm seas.

There were many other sea creatures, crinoids, oysters, shrimps. Crabs began in these seas. Such a lot of things lived in these waters. Too many to write about! Many of them still live there. Go down to the sea to learn what is there now.

Ammonites

You remember the Nautilus Family which made its mark on Page Two? Well they had some cousins which

lived in these seas of Middle Time, the Proud Ammonite Family.

The Ammonites grew and grew. A Proud Ammonite knew of nothing finer than himself, so instead of growing straight ahead he coiled around and around himself. He had a whole house of rooms. His outside room was large. He lived there. But break off the outside room and behold! A smaller room behind it! That is where he lived when he was smaller. Break the shell, room by room. There, right in the centre, is a tiny room where the Baby Ammonite first lived. He began with this one room. He ate so much that soon he grew too big for it. The shell would not stretch. So, from the lime in the water he carefully laid a floor over the smaller back part of his room and built it larger in front. Then he moved into it. He kept on growing. Soon the second room was too small. He built a third and moved in. He learned that trick from his ancestor the Nautilus. But, he could not just drop the first back rooms. They stuck to him. So he built all around them. He grew bigger and bigger and prouder and prouder. He built room after room, and over every room he built a floor.

Now, the Ammonites, proud creatures, built fancy floors with many flutings. Nothing plain for them! Their ancestors and cousins, the Nautilus Family, built plain floors, but the Ammonites would have none of it! They really started quite humbly with a few ornamental twists in the edge of the floors where they join the wall. But each Ammonite Family tried to do better than his neighbour, and succeeded.

The Ammonites flourished in the beginning of Mid-

dle Time. Then during the desert time the Ammonites died off. Perhaps they had some enemies that ate them. Anyway, a great many of them died.

Then it grew warmer again, and the warm weather trees and ferns spread all over the continents. Well, the few Ammonites that were left thought "This is our chance." They grew and grew and spread all over again, wherever they could live. Then the Earth rose. The Rocky Mountains were born, the sea drew back. The Proud Ammonites died, all of them. There were none in the Time Just-Before-Now. There are none to-day.

Reptiles and All Their Relations

What are reptiles? They are crawling things, mostly cold and clammy to touch—lizards, alligators, snakes and turtles. They are cold-blooded and most of them lay eggs, rarely paying much attention to their young.

But there was a time, during this Middle Time, when the Reptiles were the lords of the Earth.

Dinosaurs

Lord of the Reptiles was the dinosaur, and all its cousins. The dinosaurs at the beginning of Middle Time were quite humble-minded, that is, compared with their great-grandchildren who lived close to the end of Middle Time. Nevertheless, they were so lordly they stood on their hind legs, quite contrary to the usual custom of Reptiles. It is true their front legs were rather short. but they found they could run faster on two legs. Run they did, all over the land, over the mud flats where they left their footprints and their bones! We find those footprints and those bones to-day. .

If you live in Connecticut, look for them. If you live in Wyoming or Alberta, look for the bones of their fierce great-grandchildren.

The first mildly humble dinosaurs began to be crowded out by their many fiercer children. There was *Brontosaurus* and his family. He was about 65 feet long. Not a pigmy he! Then there was the *Diplodocus* family, longer than their name, at least 80 feet long. Both of these huge beasts had tiny brains. There were others like them. Some of them ate leaves and other green things. They had teeth for grinding soft food. Some of them had the great sharp, curving teeth that were fashioned for tearing flesh. They ate living things, perhaps little mammals—if they could catch them!

As they grew fiercer they became fewer in number. There was a great tyrant among them, the greatest flesh-eater that has ever been. He was called *Tyrannosaurus rex*—‘king of the tyrant reptiles’.

Dragons

There were dragons once, real dragons. For not content with being lords of the land, the Reptiles decided to be lords of the air. Back of the small front legs they grew a leathery skin. They began to fly. Not a feather did they have. True dragons they were, ugly and fearful, and such clumsy fliers. When they came to Earth they walked like other Reptiles.

We do not know what sounds they made, if any, because sounds are not saved in the rocks.

But they were different from the fabled dragons. They did not spit fire! Fire belongs to Man.

After many years the great clumsy dragons grew better, that is, more fitted to fly. They grew lighter, with

smaller bodies and larger wings—if you call them wings. Some, with a body as small as a goose, stretched 20 to 25 feet from wing to wing—if you call them wings. But their day, too, was drawing to a close. They died, all of them!

Reptiles of the Sea

There were reptiles in the sea. Fish-reptiles they are called, because their fore-legs changed into fins. They lived on fish. And I suspect very strongly, they ate a lot of the Proud Ammonites about which I told you.

Birds

And the birds? From where did they come? In some very fine rocks laid in that inland sea which stretched across Southern Europe, are a few feathers, on two small skeletons. They are bird skeletons, the first birds known. They look more like reptiles than our birds do! But think what you will! There are the prints of the feathers. There are a few teeth on the beaks, for one head is there. The other head is lost. And there are claws on the wings, like the front feet of the dinosaurs, or the dragons.

Are they reptile or bird? Since they had feathers I think we may call them birds.

There were a few sea-birds later. They, too, had teeth. But they had lost their wings, so they could not fly much. Penguins' wings have become paddles. They do not fly but they are birds. Gradually all birds lost their teeth, and became more like the birds we know.

But from where did birds come? It almost looks as though the birds were related to the dragons. Most men think they were. The early birds had flat heads, and teeth on their beaks like reptiles. Their bones were

much the same too. Both reptiles and birds lay eggs, and the young are born from them.

But there is one great difference. Birds are warm-blooded and reptiles are cold-blooded. Because of this some men think birds did not come from reptiles. It would be a good thing to find some more skeletons of early birds. We might be able to be more certain one way or the other.

The birds lived on, and became large and important in the Time Just-Before-Now.

Mammals

And then there were Mammals! Mammals are warm-blooded creatures that feed their young with milk, and all but the most lowly are born complete, though not yet grown up. We are very interested in them because Man is a Mammal.

The grasses, cereals and fruits had come to stay on the Earth. And upon them the mammals thrived. But the mammals were just beginning at this time. They were simple, small, none of them bigger than a small dog. But their brains were big. Mammals were swift. They had warm blood as we have. If your hands are cold, breathe on them. Your breath is warm because you are warm inside. Lie down beside your dog. He keeps you warm. Put your kitten on your knee. How warm it is! But a fish is not warm. It is cold and clammy. So is a snake or a lizard. But the Mammal is warm-blooded.

The first tiny unimportant mammals appeared in Germany, England and South Africa, but there were not yet any in North America. They must have felt strange and afraid. Of course, they were not so differ-

ent from the reptiles as mammals are now. We really do not know much about them. A few jaws with teeth and a skull are all that have been found. But do not despise them! These simple early mammals were to win out. In time mammals became the most important animals on the Earth.

Did men live then?

No, not even the first savage wild men. There was not one human being. But as time moved on from the beginning to the close of Middle Time we see how the Earth was being prepared.

Then They Died

This Middle Time was truly a time of great growth. The creatures in the sea grew and multiplied. But especially on land, plants and animals grew and spread. For there was a time when there was no life on land. Both plants and animals grew from simple forms to higher forms. Many of the plants lived on into the Time Just-Before-Now.

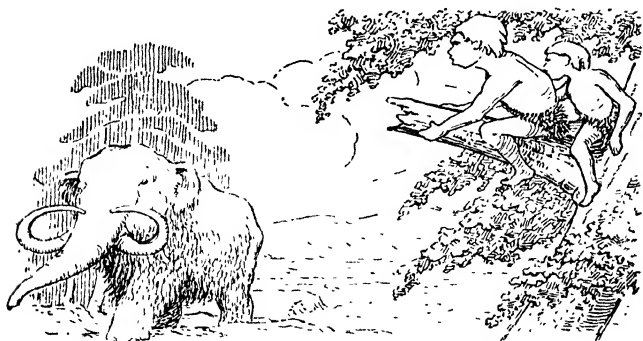
But the animals! When the Rocky Mountains were born they died! Many of them! Never to come back again. The Proud Ammonites died! The dinosaurs died! The great land turtles died! I have not spoken of them, but there were some. The dragons died! It was a time of dying!

The Little Things Lived On

But the birds lived on, and the swift cunning little mammals lived on. They could escape their more clumsy enemies. They could move quickly from place to place when the weather changed. They lived to become, in turn, the lords of creation in the Time Just-Before-Now.

CHAPTER IV

JUST-BEFORE-NOW—PAGE FOUR



PAGE FOUR has a strange new rhythm, and is most interesting for another reason—during it Man appeared.

* * *

The story on this page is not all written in solid rock. Much of it is found in the loose rock, such as clay, sand, and mud which we see lying about everywhere. Some of the things that happened Just-Before-Now are happening now, but not all of them.

This time began in quietness. So it is written on Page Four, the last page of the Composition, the Page that tells of the first man on Earth!

During this quiet time all the mountains were being worn down by rivers, frost and wind. Great thicknesses of sediments from the worn-down high places were

strewn over the lower lands. These were land sediments, dry, not cemented as they sometimes are in the ocean.

But along the ocean shore the sediments were carried into the sea. And the seashore was not where it is now, but far inland. In California, where the Coast Range now stands were no mountains at all. No, even the land was deep under the sea, and many feet of mud were dropped upon it. That mud, raised up, is now the shale that holds the oil of California.

In the east, during this quiet time the mountains, probably higher than the present Appalachians, were worn down more and more by the winds and rivers. They were almost beginning to look like plains, before the great restless Earth warped up again.

AGAIN MOUNTAINS ARE BORN!

And yet once again! Just before Man came the Great Chords of the Rhythm were struck!

The whole world seemed to be just bursting out in volcanoes, belching out smoke, ashes and boiling lava. Of course, not really the whole world but so much of it that you can hardly think of the rest.

In North America the mountains on the west were slowly rising higher and higher. There was a long line of belching volcanoes: Mount Shasta, Mount Hood, Mount Rainier, Mount Baker, and many others. Lassen Peak is still alive. The others are dead volcanoes now, but their sides are all built up with lava which poured out of them red-hot or white-hot.

In the States of Washington and Oregon the lava poured over a great basin and filled it with lava, flow upon flow, until the Columbia Plateau was built up. The great ridge of the Sierra Nevadas rose higher and high-

er, one great mass of crystalline rocks. And in the space between the Rocky Mountains and the Sierra Nevadas immense blocks of the Earth's crust dropped. Other blocks were pushed up. Now we call that area 'the Great Basin'.

In the east the Appalachians were treated more gently. They were warped up a little higher. Their streams began to flow faster and to wear them down again.

But it was not only in the United States and Canada that volcanoes belched and mountains moved. In South America the Andes rose higher and higher. In Peru there was a great lava plateau built up just like the Columbia Plateau. And remember, the Andes are higher than any mountain range in North America.

And in Europe the Alps rose up and up. In Asia the Himalayas went up, up. And remember, the highest mountain in the world, Mount Everest, is in the Himalayas.

In all these great mountain ranges, and in many smaller ones were volcanoes belching out fire.

Truly it seemed as if the Earth was on fire, and never quiet!

Which is greater—a time when mountains are born, with belching volcanoes, and rising continents, or the quiet times when mountains are being worn down?

It is a hard question. There is great noise and fire when mountains are born, but great things happen during the quiet times, too. The shifting of the sediments and of the weight of the Earth's crust during the quiet time may be one reason for the change which folds up mountains.

But the greatest thing that happens in the quiet times is the growth and spread of life.

THE STRANGE RHYTHM

Then a strange thing happened. It had happened before in one small place of which we know on Page One, and then again over wide areas late in the time when Page Two was written.

It grew cold, very cold. Do not ask why! I cannot tell you. Some men think one thing, some another. But no one is really sure, even yet. But fields, great fields of ice or glaciers covered the northern continents.

Ice and snow, in some places a mile thick, covered the northern half of North America. This was the strange rhythm that weighed our land down. Strange! The sea has come and gone many times, but only once before (the story is told on Page Two) did great sheets of ice cover large parts of the Earth.

Greenland is mostly covered with ice now, and so is Antarctica. If you sail away to Greenland you can find only a few harbours along its shore and very little uncovered land beyond. Except for the narrow ice-free rim at the shore, this large island is still covered with a thick sheet of ice. Great ice-caps like this are called 'continental glaciers'. Greenland and Antarctica are the only lands that have continental glaciers now. The other glaciers of the world are much smaller. They are really rivers of ice flowing out from ice-covered mountain-sides.

But once up in the north, not only Greenland was covered with ice, but the whole northern part of North America—all of Canada and some of the northern

States. Covered too, was the north of Europe and Asia.

How do we know the ice in North America was a mile thick in some places? Because there are mountains a mile high that were covered, and others higher were covered all but their tips. Their peaks stood like islands above the broad sea of ice and snow.

And on these island peaks grew plants of colder climates. Their brothers and cousins on the lower lands perished in the snow. Of course, plants grow in the north now. But they came up again from the south after the ice had gone, though not all our plants came from the south, for some of these true northerns still live on mountain-tops.

There is another reason for knowing the peaks were not covered. The ice was very heavy. It was so heavy that some of it was squeezed out along the edges. As it moved over the hills it tore off all jutting, jagged rock edges, and all sharp pieces. The loosened, broken rocks became frozen in the ice, and moved on with it. Like great scrubbing brushes the ice with its rock rubble just scoured off the tops of all other mountains and left them rounded. So when we find a high, rough, jagged peak we know the ice never scrubbed that mountain peak.

Where the loosened rock pieces were frozen in the bottom of the ice, they were scraped along the ground. And did they scratch it! The ice-cap used the boulders like a huge slate-pencil. They wrote just exactly the direction in which the glaciers moved. The words are the scratches and grooves they made in the flat rock surface over which they slid. We can read them now.

Sometimes scratching along the face of the Earth, or scrubbing off mountain-tops, the boulders in the ice were themselves crushed to bits, smaller and smaller, or even worn to powder.

As the glaciers reached the valleys, or came farther south the weather became warmer. The ice melted. It rained, and melted more ice. But, after a long time it grew colder again. Snow fell instead of rain. The ice-cap grew thicker again and heavier. Its edges pushed southward again, covering up all that had happened during the warmer weather.

What had happened in the warm spell? What became of all the boulders, large and small, the torn off mountain-tops ground to powdery earth—what happened to them when the ice melted? They just dropped where they were, higgledy-piggledy, big and little together, with earth or coarse bits of rock between them. Then weather, winds and water got busy. Soil was made from these broken up mountain-tops. Some of the iron in the rocks rusted. Other changes took place. Once or twice the ice almost disappeared, then it grew colder again, and back came the ice for a long time. Several between-soils are found in Illinois, Wisconsin and other places. Plants grew. Near Toronto, in one of these between-soils there are tree branches, not north-country trees, but warm-weather trees.

But when the ice finally all melted, think of all the water! Lakes and rivers! We find their beaches and shores now. In places the water sorted out some of the mixed-up piles of loose boulders, let free some of the sand, and carried the finer clays out into the many lakes, where it gradually sank to the bottom. We find the clay

now, spread in layers over the country-side. The layers are called 'varves', from a Swedish word meaning ribbon, because when cut, the thin layers are like ribbons.

So, in large areas the ice-cap left the whole country-side covered with boulder hills, partly sorted in places, with varved lake-clays in places, with washed-out soils in places. None of it really belongs where it is. It came from farther north. But, nevertheless, there it is, in Canada and the Northern States.

That, all that, is one strange thing that happened in the Time Just-Before-Now.

And then in North America!

The sea came up over the fringes of the northern part of the continent. Over the edges of Europe and Asia too! Not very much, but still it lay in spots and hollows where you never see it now. In North America it came away up the St. Lawrence and down into Lake Champlain. It left sea-beaches and sea-shells far up the Ottawa valley.

Why did it come? 'Because the continent had been weighted down by the ice and it took a little while to rise again. The ocean seized the chance to get another look far inland.

And so, these are the things that took place on the Page Four of the Earth's history, Just-Before-Now.

AND THE LIFE ON EARTH!

Plants

Among the plants were some of the trees that shed their leaves for the winter. They grew and spread. And flowering plants, such as we know! It was the beginning of the Earth as we know it now.

In the Sea

Some forms of all the animals that lived in the sea, still lived there. There were still tiny one-celled creatures. There were still sponges. There were still corals. There were still clam-like and snail-like forms, but they were very different from their great, great, many times great-grandparents. There were still fish, more of the kinds that we know now.

Mammals

And so you see, there were a great many animals during this Time Just-Before-Now. There were many others about which I have not spoken. Some of these animals lived on, and some died out.

This last Page, Just-Before-Now, was the time when mammals, the wisest and cleverest group of all the creatures, first appeared in great numbers, and grew and spread all over the Earth. The time of this Page is sometimes called the 'Age of Mammals'. There had been a few primitive ones before, as you know. But now they grew stronger and wiser and swifter. Finally, the wisest of all—Man—appeared. Even he grew, and learned to live on almost all the lands of the Earth. But Man has much, very much to learn yet.

Horses

There was the horse, one of Man's greatest friends. The kind of horse you know now is not like the first horse. Even the wild horses of to-day are smaller and tougher than our thoroughbreds. But these horses of the time of the glaciers and before were very strange.

Look at a horse's hoof. A horse-shoe is fastened to his one large toe or foot bone. But this early horse was much smaller and he had three bones, like fingers or

toes, one large one in the middle and two smaller ones, one at each side. Even before that there was an earlier horse that had four toes on his front feet and three on his hind feet. He was a wee little horse, just about as big as a fox-terrier, small and quick. He lived on leaves and tender shoots of trees in the forests. He had a lot of enemies, much bigger and stronger than himself, but they were not so wise as he. He used his intelligence and his swiftness to keep away from them. And this little horse grew and changed.

And finally evolved the horse that we know to-day.

QUEER, BUT A MAN!

And then came Man! Not in America—at least, none of his bones have been found here. This first group of men possibly lived in southern Europe or Asia.

* * *

It is evening away off in Persia. A dark cave on a hillside! A man comes to the cave mouth. The setting sun falls upon him. He looks like no one you have ever seen before. He is short and thick. He has a wide nose, heavy eyebrows, a low forehead, almost no neck, short squat legs and large feet. He needs no clothes. He is covered with hair. In his hand he holds a bone, from which with his strong teeth he tears great chunks of meat and swallows them down. His face is big-featured and, well—brutal, that is, if we compare it with that of an ordinary man now. But compare it with that of the beasts around. It is more cunning. There is a dawning intelligence.

And he is more intelligent than the animals about him. He makes himself stone tools. He makes fire,

though he sometimes eats his meat raw as you see. But he has learned that fire keeps him warm. In his caves are found traces of fires. This man has no bow and arrow. He never saw one. He never even imagined one. And yet he is a hunter of big game, bison, cave-bear, horse and reindeer.

We know he was a big-game hunter because we find his bones with the bones of the big animals. And with the man's bones we find his simple stone tools. He was buried with them.

The oldest skeletal remains have a skull which slopes back like that of living apes. There is not a real chin and the mouth and jaw project far out.

Skeletons of ancient man have been found in several countries of Europe, Africa and in Asia: in Mesopotamia and in China.

Why were these early men so different from us of to-day? And why so ape-like in appearance?

Well, all life, no matter how lowly or how high, has slowly changed through the ages. And in that change, especially with the animals, bigger and better and stronger types have developed. They have learned better how to defend themselves from their enemies and how to live. Gradually changes took place in their bodies.

We human beings did not just happen. We are much more important than that, for we are a part of this great change. Our story began away back before the great Glacial Age. Our very distant ancestors in some ways looked like the gorillas and other apes now living, but they were more intelligent. Away back, long before that, all of us probably came from the same

early form. Just what that was we do not know yet. Some day probably other skeletons will be found that will help solve the mystery.

And is it not a much bigger thought that we are growing to something better and better, than to be just made, ready-made, like a piece of magic? We are part of a great development, a very important part. And development is law and order and growth.

And so Man too, developed. He learned to use tools, to tame some of the animals.

Did Boys and Girls Live Then?

There were men. There were women, and of course boys and girls. Were they like us? How did they live? What did they eat and wear? What did they do? And where did they live? Of course, they did not live on the glaciers. They lived farther south where the ice-cold climate did not reach them.

* * *

Thousands of years have passed.

* * *

There, on the hillside, a skin tent is pitched. It stands alone. The flap is lifted and a boy comes out. He stands for a minute, his hand on the rope that pulls the tent flaps tight. The rope looks queer! It is not a rope! It is all made of skin.

The forest is different, too. That tree over there is strange. It is a lighter green, standing out against the dark evergreens. Its leaves are divided into two parts. They flutter in the breeze. It is a gingko tree. There are gingkos now—in Japan. There are a few in the United States and in Canada. I have seen them, in

Washington and in Ottawa, but they were brought there. They do not now grow of themselves in the North American forests.

The boy stoops and picks up a bow. He takes some arrows from a pile. Each arrowhead is of delicately chipped stone. Some have a toothed edge. Some of the shafts have notches and ornaments down the sides. Perhaps these notches mean his father's name. Perhaps his father is chief of the tribe.

The boy runs to a woman, and says something. I do not know the words. They are like no living language. But the woman understands. She lays down a long coarse leather sinew she uses for thread, and a bone awl with which she makes holes in the skin over her knees. She is making a crude garment for the boy. Proudly he puts it on, and hurries to the trees at the edge of the bush.

All along the edge some wild wolf-like dogs are fastened far apart to keep them from tearing one another to pieces. For they are wild, and they are hungry. Their masters want them to be hungry because they will hunt better.

Some women and naked children come along from the huts near the swamp. They all jabber together, words of the unknown tongue. The boy hands each dog-lead to a different woman. The dogs must still be kept apart. They pull, snarl and snap. But the women are sturdy and strong, and are able to hold them.

Again the tent flap opens. A man comes out. He is tall and straight. His chin is strong, and he has a fine high forehead. He is almost like the men we know. He picks up a long, heavy spear, and strikes a blow at the

howling dogs. He turns to the woman who was sewing and says some words in that unknown tongue.

The men, women and children all jabber together, and shout at the dogs. They make a fearful noise. They seem to be angry but I do not suppose they are.

They all need food. The rest of the men have gone to hunt for it. Perhaps they will rob another tribe if they do not find food, and if they find another tribe in this lonely country. And they might even eat their enemies if they cannot get food any other way. Who knows? They are savage people, but wiser, far wiser, than the animals about them. And a long time after their descendants became still wiser. They learned to live together, to study and learn, and to use the forces of nature, like the wind, and electricity and many other things. Even now in our day man has not yet finished his growth.

But this boy and this man are living long ago. They go on through the bush, over plains with short grass. They see a monstrous woolly rhinoceros coming up from the edge of a river. He is too big and fierce for them alone. By signs which we would never see, perhaps by smell, they trace some of the other hunters, one by one.

See! The hunters have killed a great bear. There will be meat for all. They hide it safely and then turn back to stalk the rhinoceros. It is a fierce fight, the men have their arrows only. Two of the men are killed and trampled by the great beast, who like the men is fighting for its life. Two of the dogs are killed too, and another dies from wounds later.

Some of the men go to a cache. (They do not call it

that. I do not know their word. 'Cache' is a French-Canadian word meaning a hidden store, usually of food). On the way they kill a great tiger with long upper teeth. Sabre-toothed tiger, men call him now, because he had teeth like a sabre.

The hunters see him behind some trees near a clearing. With blood-reddened mouth he tears apart a small deer-like animal which has not been swift enough to escape him. The tiger is so greedy, or so hungry, that he does not see the men. He is on the wrong side of the wind. It is blowing their scent the other way. They see him soon enough to hold back the dogs. The men creep nearer. They almost miss him. The first man is so eager to get him he shoots too soon. Several arrows strike the tiger and then the wolf-dogs are let loose. It is a terrible fight. But they get him. The tiger's skin is badly torn, especially about the head. But there is still a good piece of it left. It will be used for clothes or something else.

The hunters turn back to the village with their kill, back to the hungry tribe. There will be food. There will be warm furry skins. There will be more skin for tents.

Now the boy and his father leave the other hunters. They go on. They want to see more. Each leads a dog by a long thong fastened to his arm. They come out of the bush to a stretch of wilderness. Tufts of coarse grass grow around. They hear the quick sharp sound of many feet. Peering from behind a bush they watch a herd of wild horses. At a sound or a whiff on the wind the horses fling back their heads and fly in a dusty panic across the plain. Their sharp hoofs beat into the hard ground, horses with quick feet!

Night comes on. The dogs are fastened well apart from one another. If any danger comes at night, the dogs will hear or smell it. With their arrows and their stone knives the man and boy just roll under a bush to sleep.

In the morning the boy awakes suddenly. He hears a croaking sound. It is something new. He raises himself stealthily on his elbow and peers out from under the bush. He sees a great vulture-like bird, not far from him. In a moment several clumsy birds fly along heavily near the ground. They slowly pass out of sight, sometimes walking, helped along by their large wings, sometimes flying awkwardly above the ground. The boy wonders "Why can birds stay up in the air?" He jumps up and tries himself to spring into the air from a little hillock. It is no use. He falls heavily to the ground. The movement wakens his father.

What the boy says to the man in that strange language you can imagine. There were not many birds then, when the glaciers were slowly withdrawing to the north. So this was quite a sight.

Together the man and boy tear up roots for breakfast. They taste good. It is much easier than hunting. Then they push on northward. They do not know they are going north.

But they must be. At noon the sun casts their shadows that way.

Farther and farther north they go. One day they hear a loud trumpeting. Not even the man has heard it before. They climb a tree and 'freeze', like all wild things. For they are wild, though they are men. They remain absolutely still. Down the slope and over the

glade comes a great animal, with long curving tusks and a huge trunk. He looks like an elephant but is larger. He is one of the great, great-grandfathers of elephants. He is covered with fur, like the rhinoceros they had helped to kill, weeks ago it seems now. They wait breathlessly. With its long trunk the great creature pulls up the coarse grass by the roots. It even reaches high in the trees and rips off the leaves. The man and boy climb higher. But the hairy mammoth, for that is what he is, lumbers on, eating as he goes.

One day through the bushes they see a swiftly-moving animal, smaller than our deer, come over the scrub to drink at a near-by stream. He drinks, makes a peculiar grunt and then moves on. The man and the boy speak. I do not know what they call it because no one knows their words. But it was a kind of camel, though it had no hump, or only a very little one. For camels, too, once lived in North America.

There were many other animals. There were giant sloths, and giant pigs, and many other creatures with queer names. Most of them are gone now. But the man and the boy could not see all there were. North America is so large, and the animals did not all live in one part of it.

In the late afternoon, weeks afterwards, they come to a rocky hilly country. Just at dusk they see a great, grey shadow lumbering around a point of rock and then disappear into a cave. It is a cave-bear. Now, the man and boy are hungry. They have eaten berries but the flat country with the roots is far behind. They have not been able to kill anything all day. The boy has never seen a bear like this before, but the man has. It is dan-

gerous, but they have no food, and bear meat is good.

They tie the dogs far back above the cave, and look well to their bows and arrows. Then the man creeps down and with two pieces of flint starts a fire in front of the cave.

No animal can build a fire. Animals are all very curious about it, though. Did you ever watch a young cat in front of a grate fire, the first he has ever seen? He is terribly curious about the strange flickering of the flame.

So is the bear in the cave. Besides, the smoke chokes it. The bear comes out with two cubs. It ambles towards the flame. The cubs follow. Curiously they nose about it. The man and the boy wait behind boulders above. Then they loose their arrows. The arrows fly straight. They are good hunters. In a trice the cubs are killed but not the mother bear. Wounded and bleeding, enraged at the death of her cubs she charges up the hillside. Both bows twang as two more arrows fly and the man and the boy dodge behind boulders farther up. The man shoots another arrow through the bear's eye, just as she strikes at the boy. Her forepaw claws down the boy's leg, but the bear falls dead. The man staunches the bleeding leg with leaves and what grass he can find. But the boy is helpless for days.

Afterwards when the boy became a man himself he remembered the place with the roots good to eat, and the strange creatures that flew in the air. He and others with him came north and made this their home, at least for a time.

* * *

And as the glaciers drew back, the plants and trees,

the animals and finally mankind moved farther and farther north.

This is a true story. It happened in Europe and it happened in North America. I do not know the name of any of the men and women, boys or girls. But I know it is true. Mammoth bones have been found among the glacial gravels, in Europe and in America, and in burial places we find the bones of the men, and animals, bones and arrows with them.

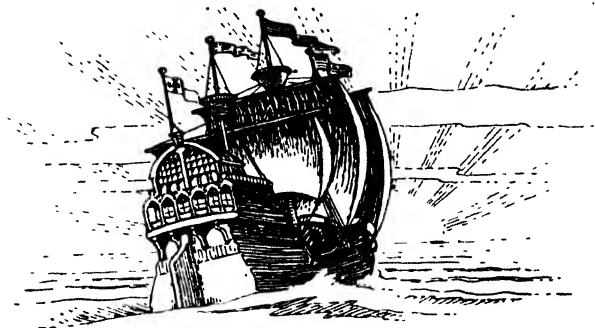
But, you say, "There are no tigers or elephants or camels or rhinoceros in North America." Not now, but there were. Their bones are found. And the tools of the man and the boy, and pictures they drew on the rocks. I have seen some of their pictures in Arizona. Many of the things they used are found in Mexico. Some day you can see for yourself. There are, also, many of their pictures in the caves of Europe.

Those warm-weather animals left in America, the mammoths, elephants, camels and others, were killed when the final glaciers came down. Perhaps they starved because there was so little food. We do not have sabre-toothed tigers now but we have lynx and bob-cat. Both belong to the tiger family.

Just when man came to North America in the first place we do not know. Nor how he came. But most people think that he came here from Asia—across Behring Sea to Alaska, and then down the continent, and thence spread from several centres over the eastern part, and along the northern coast. When the white men first came to North America they found the Indians living here, and the Eskimo. But that was many thousands of years after the glaciers had melted away.

PART III
THE EARTH A TREASURE
STOREHOUSE

INTRODUCTION



HAVE YOU READ about the pirates of the Spanish Main? They were sea robbers, lying in wait for the Spanish ships from the New World—ships laden with gold and silver and precious stones—Treasure!

Do you belong to a club? If you do you have a president, a secretary and a 'treasurer'. The treasurer keeps account of all the money belonging to the club.

Even a country, no matter how small or large it is, has its 'Treasurer' or 'Treasury Department'. In United States or in Canada, each state and each province has its 'State Treasurer' or its 'Treasury Department'. Each treasurer is in charge of the money spent by its Federal, State or Provincial Government.

What do we mean by 'treasure'? Of course you know. A 'treasure' is something precious, something valuable.

What things are valuable?

To the pirate of the Spanish Main, the gold, silver and precious stones were valuable. But why were they valuable? He could wear a few diamonds and rubies, or gold rings in his ears, but only a few. No, these things were not valuable to him just because he wanted to have them, but because he could sell them and get the things he wanted. Maybe he wanted to buy ships, maybe adventures, maybe he wanted power, maybe fine clothes.

The treasurer of a club or of a country takes charge of the money belonging to the club or to the country. But the money is not valuable in itself, but for the things it can buy. It may be sheets of music, if it be a music club, or rolls of film if it be a camera club. If it be a science club the money may be used to carry on some great experiment that will help all the country or all the world. The money belonging to a country may be used for roads, or hospitals, or education. These are the things that make our lives comfortable and happy.

What are the treasures of the Earth? For the most part they are common, everyday things. Some of them we have without trouble, without thought. One way to understand how important they are to us is to think of doing without them.

What would you do if the sun never shone? Could you grow food? You could not get along without sunshine.

What would you do without water? You would soon die. Many people have died because they could not get it.

The sun shines and we do not have to do anything about it. But someone before us has worked hard that we might have water, from a tap, or from a pump.

What would you do without—well, nails or screws? They are very common, not beautiful! But just think of all the ways nails and screws are used. It would not be very easy to do without them.

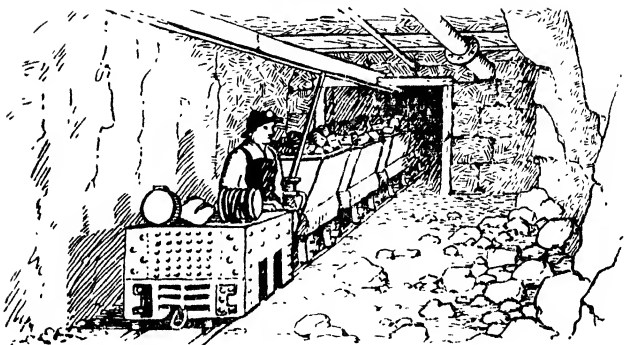
What would you do without—well, mud? The common soil in which we grow our food! You could not have a garden or farm without soil.

So many common things are treasures! And these are the things we really need in life, not the stones that glitter. The stones are beautiful and we all want beautiful things. But first we need the treasures that make us comfortable and happy so that we can enjoy the beautiful things.

Our Earth is full of treasures. Some are free, like the sunshine. But for most of them we must work. There are very many treasures in the Earth. I will tell you of only a few. Some are so common we hardly remember they are treasures. But they are, and if we had to do without them we would feel very sorry for ourselves.

CHAPTER I

GOLD



To gild refined gold, to paint the lily
 or to add another hue
Unto the rainbow

King John—WM. SHAKESPEARE

NEARLY EVERYONE has seen gold, and many people have something made of gold.

Do you have a fountain-pen? If you have, look at the nib. It is gold. Someone in your home may have a gold watch, or a gold ring, or a locket. Sometimes we read of very wealthy Indian princes eating from gold plates. It sounds like the Arabian Nights. But, there really are gold plates and they do not all belong to Indian princes.

Gold, pure gold, is yellow like sunshine. It does not change colour. It does not tarnish. Neither acids in the

air nor in water change it. That is one reason it is so valuable. But there are some chemicals that will dissolve it, given time, a long, very long time. Fortunately they are not often found together. Gold will wear off but not rust off. Pure gold lasts almost forever.

Gold is really quite soft. You can hammer it flat. Sometimes churches have parts of the ceiling and pillars covered with gold hammered thin. I have seen one in Peru. Gold-leaf, men call it. But most of the gold we use is not pure. Pure gold is too soft to be useful. It has to be mixed with other things to harden it. When your grandfather was a boy and long before that, gold was mixed with copper. It was reddish-yellow in colour. We call it old gold. Now, gold is usually mixed with a little silver, making it a cold, clear colour—white gold.

OF WHAT USE IS GOLD?

All the world seems to be struggling for gold.

Yet on an island in the far north, in a desert, or in any other lonely place gold is of no use. On a desert island you want a fish-hook, a rifle, water or fruit. You probably could not live very long without them. But you could get along there without any trouble if you did not have gold at all.

Why do we struggle for gold then? How do we use it?

It is beautiful, so we use it for its beauty—for the watches and rings and locketts of which I have spoken. There are many more very beautiful ornaments and useful things like bowls or vases, too many to write down.

We use gold for other things. It is used for mending teeth. Even if you do not have a gold watch or ring or

locket, you see people almost every day with gold in their teeth. Why is it used there? Because acids in the mouth do not dissolve or tarnish it. Pure gold lasts longer than almost anything else. There are many other ways too in which gold is used because of its purity.

But none of these is the reason the world struggles for gold.

It is scarce. It is hard to find. It costs effort, time, money. Men suffer and sometimes die to get it. Why?

Most boys and girls in North America have played 'Indian' at some time or other. When all dressed up in your feathers you may want to get something from another Indian, a friendly Indian. You do not want to fight him for it. You want to buy from him. Indians did not have money like ours. So you have no money when you play Indian. What are you going to use for money? You use what the Indians call 'wampum'. It may be a string of shells. You cut off a piece of wampum when you want to buy something; a little bit for something cheap, like a wife; a long bit for something very valuable, like a tomahawk.

When the white man first came to North America he had money, but he could not use it to buy from the Indians. They did not want it because they did not understand it. They used the wampum for trade. The white man did not have wampum. But he did have something the Indians liked and wanted. He had bright beads, and guns, and small glittering trinkets. The Indians liked the bright beads, especially for their moccasins and belts when they dressed up for war dances.

Some of the peoples of Africa and Asia still use cowrie shells for money.

These different kinds of money are all very well if the trading is just in the tribe, or with others using wampum or cowrie shells. But if people move around and sell things from one country to another they have to find something that the people in other countries value. So gradually gold came into use for buying things, and became money.

Did you ever see gold money? Probably not many of you have done so. You cannot get it now, even at a bank. But it is there just the same. Sometimes when most of the gold in the world is moved into one country, other countries say it is of no use to them so they do not use it for money any more. They begin trading as boys trade. "I will give you a jack-knife for so many marbles," or, "I will give you so much of my wheat for your shipload of cloth." We say those countries have gone off the 'gold standard'.

The question is a big one. Why use gold that you never see, for money? Some people think it should be used and others that it should not. But this is not the place to study that matter. What we want to know is, some of the uses of gold. And money is one of them.

WHERE DO WE GET GOLD?

If gold is so very important, we should know something about where it is found. Gold is found in the rocks in the Earth, and for centuries men have been taking it out of the rocks.

Let us go down into a gold mine to see how they get it out.

First we go into a huge shed. Why is this, we wonder? Because there is a great deal of machinery that

must be protected from the weather. There is the top of the elevators and shafts, and the electric dynamos that pump air into the mines and keep the lights going away down below the surface.

This is a big room, isn't it? and rather dark. We must go over to that smaller room at the side. We'll get rubber coats, rubber boots, and helmets there. We'll need them because it is wet in the mine and not very clean. There will be crushed rock and dripping water, which do make a mess.

What a funny elevator! Wooden slats on the sides to keep us in! How do you like going down into a hole in the earth? We won't be taken right to the bottom, because this mine goes down very far into the Earth. More than a mile! Think of a mile along the ground, of a house that is a mile away from yours. Now think of how deep is a hole a mile down. A long way, is it not?

But we will only go down part of the way, perhaps half a mile. That is deep enough to see what is done in a gold mine.

The elevator has stopped. The slat door opens. Don't stand up too high, or feel too proud of yourself because you are down half a mile in the earth in a gold mine. You are sure to bump your head if you do.

Here is a long tunnel with other tunnels branching off from it. It is low and pretty narrow, and crowded along the tunnel floor on one side is a narrow, rather shaky track for the mine cars.

We don't need to be afraid of rocks falling on us from the low ceiling, because it has been cemented over.

This has been done for the safety of the miners, and of course for the safety of the visitors too.

The lights are a bit dim. But our eyes will get used to this half-darkness soon. There are some irregular shoulders of rock jutting out that hide some of the lights and make long irregular shadows.

You can see the miners further along in the tunnel. They are shovelling broken rock into little cars that look like glorified wheelbarrows. See how the cars are wobbling along the narrow track. Flatten yourself against the side of the tunnel so that they can pass, because the track is very near the wall.

Let us follow behind the line of cars. It is rough walking, with the water sludging up between the ties, and the loose chunks of rock that have fallen from the cars. I am glad we have rubber clothing. There is water dripping everywhere from the uncovered parts of the roof and sides of the tunnel. It reflects the lights and adds to the shadow confusion.

The tunnel is widening into a gallery. It is almost a room. There are several miners here. The cars have stopped. The rock is being dumped into a big hole.

Come over to this side and look down into the hole. See those two steel plates with great rows of steel teeth all across the flattened surface. They are moving back and forth. They rub against one another, crushing the rocks in between. The motion is almost like rolling something between your hands. But the toothed plates chew up the rocks. The crushed rock material falls on to a carrier below which takes it to a shaft and up to a mill.

Now let us go back to the elevator and up to the mill to see what happens to the crushed rock.

It is good to be up in the daylight again. First, let us take off our rubber things. They are so hot. The mill is above ground, so we do not need the rubber clothes.

What a terrific noise the machinery makes here! We cannot hear ourselves speak.

First, we will go over there where the crushed rock enters the building. There is a revolving mill. Revolving is not quite the right word, because it is not going round and round, but turning this way and that.

The rock is crushed pretty fine in the mill. Now it moves on down into a great boiler-like crusher, that is filled with steel balls of all sizes from a golf ball to a tennis ball. The rock is whirled around and around, and ground finer and finer until it is just a powder. Then it is passed through a fine screen or sieve. There are 200 wires to an inch in that sieve. Very fine indeed!

The next thing that happens is a bit difficult to understand. You really need to know a little chemistry. The rock powder is mixed with water and a chemical called cyanide of potash, and is passed down through a row of rubber-faced discs. The gold solution gets inside the discs but the fine powdered rock sticks to the rubber. Then air is pumped into the discs. The rubber-facing puffs out and out like the cheeks of old King Cole. The cheeks puff out so much they touch a scraper nearby, which rubs off the rock powder. It falls into water and is carried down into a ditch. This thrown-out rock powder looks like grey goo, and is called 'tailings'. You can see it in great ponds near mining places.

The gold-bearing liquid is cleaned out of the discs. The gold is then separated from the water.

Where does the gold go then? It is taken into an-

other building and the few impurities left are taken from it. Now it is pure gold, and is melted into a brick—a gold brick which is very heavy!

Then it may be sent to a mint, where it is made into money, or it may be just weighed and valued. There is a mint in Washington, and there is a Royal Mint at Ottawa. There is a Royal Mint in London, England, too, and in other world capitals.

HOW DOES THE GOLD GET INTO THE ROCK?

Did you see any gold in that dark rock down in the mine? I did not, and probably you did not either. Where is it, then?

Usually it is in such fine particles that you cannot see it. But there it is all the same. Generally it is in tiny flecks in veins of hard white quartz rock. The quartz vein may be wide and clear, or it may be just a thin streak criss-crossing another rock. Sometimes gold is found in detached, pebble-like blebs of all sizes that are mixed in with gravel.

But how did it get there?

In the first place gold comes from great depths where the heat is so great the rock is melted. In this great heat all or nearly all the water in the rocks becomes steam. In the steam-vapours are other gases, and even dissolved minerals. Some men believe even gold may be there in solution in the steam. For gold, as we read before, will dissolve in some things with time and a high temperature. Other men believe the gold is dissolved in water that has not turned to steam. There are minute quantities of gold even in sea-water now.

But how does the gold get up near the surface where the miners can reach it?

Melted Masses

Do you remember what happens when mountains are born? The surface of the Earth heaves up. The space beneath is filled with melted rock which is welling up slowly. And, in some places, there is gold in these great masses of melted rock. As the rock slowly rises it cools, becomes stiff and finally is hard and crystalline. As I explained before (page 11) many minerals are in crystals because of the slowness of the cooling of the hot melted rock beneath the surface. There may be a great dome-shaped mass of rock lying, perhaps hundreds of feet, below the surface. It has bowed up the rock above it into a mountain range. Above it through the centuries the wind, rain, ice and rivers wear down the mountain-sides. Some is worn off here, some there. Patches of the dome of slowly-cooled rock are laid bare, like spots of grass on the hillside when spring is wearing off the snow and ice. And there in it, in places, is the gold.

Fault Faces

When mountains are heaved up the sides cannot always stand the strain of pushing. Sometimes cracks are made in the rocks and one side is shoved up over the other. The hot melted rock pressing up from below pushes into the lower end of those great breaks, steals along the face of the fallen blocks and in and out of any hole or slit it may find. And in front of it, the melted rock pushes the vapours and gases, some of which may have gold, or the water bearing the gold solutions is thrust upward by the expanding gases and vapours.

These great broken rock faces are called 'faults', and gold is found in some places along them.

Dikes and Veins

And everywhere along these great breaks are smaller cracks. The strain of mountain-building is felt for miles on either side. Not all the rock will break, but much of it may crack. The cracks close or widen with the mountain movement. They may be several feet across or less than an inch. And into these cracks, too, a thin stream of the boiling rock will push, thrust up from below.

The stream of melted rock becomes a thin rivulet. The vapour becomes a mere wisp, or the water a thin sheet. The rock is cooled more quickly now because it is a narrow vein. It stiffens. The vapour wisps and water are cooler too. The rock finally hardens. There may be gold in it, and quartz too, for quartz, like the gold, is likely to be in the vapour or water solutions. Melted rock that cools in cracks like this is called a 'vein' or 'dike'.

Sheets

In places the gold and quartz-laden vapours and water moving along in front of the melted rock find a thin slaty bed. They press their way in along the surface of the bed. They make a thin sheet of rock. When they cool, quartz and gold may be found there too.

It is very difficult to know why the quartz and gold choose one bed instead of another. But it has been noticed that very often the gold is found in beds of slaty rock.

The gold-bearing rock whether it fills in cracks or is in sheets, like the large masses of melted rock, may

cool far below the Earth's surface. But after many thousands of years, the surface is worn away, and these rocks, too, are laid bare with their rock-filled cracks and gold-filled slates.

Very often the filling in the crack is harder than the rock itself. The weaker rock on the sides of the crack wears, leaving the solid crack standing up like a ridge.

Volcanoes

Gold is sometimes brought to the surface too when melted rock is hurled from volcanoes. Volcanoes long ago threw out small quantities of gold, and living volcanoes are still throwing out some.

GOLD IN QUEER PLACES

Gravel

But gold is not always found buried in the hard rock. Sometimes it is found loose in gravel along streams and other places. How did it get there? Well, the winds, frost and rivers may wear down a mountain-side which is crossed and re-crossed by great breaks, or by gold-bearing veins. The ice cracks off great boulders. The river at the foot of the mountain helps to break up the boulders into smaller pieces. Parts of the rock are dissolved and soon the big boulders become little boulders. They are rolled down the river-bed, becoming smaller and smaller, until they are just gravel. The boulders with the gold that was once on the mountain-side gradually becomes separated from the rock that holds it. Most waters do not have the chemicals which help to dissolve gold. So the gold remains mixed in with the rock pebbles. And they all roll downstream together. But gold is heavier than most other rocks and drops

sooner. The pebbles of gold in the river gravels are called 'nuggets'.

The great gold rush to California and later to the Klondike in northern Canada was for pebble gold, or 'placer' gold as it is called. There is a lot of it in South America, too, in Peru and in other places.

When people with little training go out to look for gold, they are called 'prospectors'. They may be untrained but they learn a lot just by trying. The first prospectors at a placer stream 'pan' the gold. They dip up a panful of the gravel and water. They shake it and shake it, letting the small stones on top fly over the edge of the pan. The heavy gold pebbles are finally left together in the bottom and can be picked out.

There is gold in gravels in northern Canada and Alaska. But the gravels are all frozen together for many feet below the surface. They are melted with great streams of water. The gravels are scooped up then by machinery and ground up into fine bits. Then they are put through great water sluices where the finer crushed rock is carried off, and the gold recovered.

Gold May Be in Water

Men once thought that gold could not be dissolved, because acids would not 'eat' it. But now it has been found that it can be dissolved when certain other elements are present. It takes a long time. But gold is dissolved and is carried away in water. Not all water contains gold, not even the ocean has enough to 'drop' it in any quantity.

But, if there is too much gold and other minerals for the water to hold, even when dissolved, some of

the gold may 'settle' out. And there is the gold, sometimes in the most unexpected places.

But of course this gold, too, first came from great depths in the Earth.

HOW OLD IS GOLD?

Most of the gold in the world is found in the very old strong rocks that were shifted and tossed, melted and perhaps remelted. It may be as old as the beginning of the world so far as we know.

But there is some gold in the younger rocks too, in Olden Time, and indeed in Just-Before-Now-Time. For always when mountains are born rocks are cracked in many places. And water and vapours carrying gold and quartz and other things fill in the cracks. These are veins and dikes that I have told you about before.

In Australia there are gold-bearing veins in rocks which were laid down during the time the trilobites flourished and grew prosperous. That is much later than the gold-bearing rocks of the Canadian Shield where the very old strong rocks are.

The Rocky Mountains and the Andes, you remember, are quite young—for mountains. They, too, have gold but it was formed many millions of years after the gold in the time of the Australian trilobites.

And, of course, as we have told you gold is being separated from the rocks all the time, and is found in gravels.

Add It All Up

So, you see, gold may be found in rocks formed at any time from the beginning of the Earth until now.

PLACES WHERE MEN FIND GOLD NOW

It is very important that we know where to look for gold. Not everybody can find it. But if we know a little about how it was formed we know better where to look for it.

Since gold comes up from great depths one place to look for it, we have found, is where there has been mountain-building. That is, the places on the Earth where mountains now stand, or where there are the roots of ancient mountains.

North America

There is much gold found in North America. On the great Canadian Shield it occurs across the north of Manitoba, Ontario and Quebec, where the long-ago mountains are worn down. It is found along the dikes and veins that poured into the cracks when the rocks were crushed into mountains. A little of it occurs in Michigan and Minnesota, in the very southern part of the Great Shield.

In the east some gold is found in Nova Scotia, and in the Appalachian Mountains, right down into Alabama. There is not nearly as much, though, as up on the Canadian Shield. This gold in Eastern United States is found in rocks of different ages. You remember the Appalachians were pushed and twisted several times. Each time melted rock welled up from below and the gold-bearing solutions and vapours were thrust up through the fissures. In Nova Scotia, the gold is in the rocks of Page One, and also at the beginning of Olden Time, Page Two. But farther south the gold vapours and solutions pushed through much later. Some of them came when there were ice fields near the Equator.

Gold is found along the Pacific coast. The Coast Range here was raised up from Behring Straits all the way south to Lower California.

In many places along the sides of the pushed-up rocks in Alaska, in Yukon Territory, in British Columbia, and in California gold is found. It is also found in the Sierra Nevada Mountains in northern California. The gold, then, in these rocks is many millions of years younger than that in the Canadian Shield. It came during Middle Time.

And then gold is found farther east in the Rocky Mountains of British Columbia, Idaho and Montana, and all down the mountain range to Mexico. In Montana it is in the ancient rocks that were once laid in the Rocky Mountain trough. It welled up from below and pushed into them when the rocks in the trough were raised to mountains in Middle Time. The gold farther south is mostly in the younger rocks that were made in Just-Before-Now-Time.

South America

And gold is found in South America, too, in many places all along the Andes. You remember the stories of the Spanish treasure brought from America.

Africa

But the greatest gold country of the world is the Rand, in South Africa, where the rocks are strongly folded, crushed and twisted.

And Other Countries

Gold is found in Europe, too, in Australia, in Russia, India, China, Japan. Indeed, there are few countries in which no gold at all has been found.

And so gold is one of the treasures in the Earth's great storehouse. It has been brought up to us when the rocks were being crushed and pushed about. When the Earth's crust was being torn asunder the precious gold came up.

CHAPTER II

COPPER

WHERE DID THE WORD 'copper' come from? The Romans got the copper they used, and they used a lot of it, from the island of Cyprus. So they called the metal 'cyprium'. Look at your maps again. (I hope you have not put them away.) Cyprus is an island in the eastern end of the Mediterranean Sea. Later the word was shortened to 'cyprum'. Then a long time after it was spelled differently and written 'cuprum'. From that grew our word 'copper'. In France the word grew into 'cuivre', and in Germany it became 'Kupfer'.

SOMETHING ABOUT COPPER

Like Red Gold

Try to get a new cent or penny from the bank. Look at it. Put it beside a piece of gold, a ring or watch. It is redder than the gold, isn't it, a warmer colour? I hope you have a copper kettle in your house. Long ago there were copper pots in every kitchen. I remember an old grey-green copper pot which stood on three legs. It was supposed to be old-fashioned when I was a child, and so was kept out in the woodshed. Copper pots are no longer old-fashioned. They are prized now. But they are not used for cooking. They are polished bright enough for a mirror, and stand glowing in a place of honour, holding the biggest fern possible.

When it is polished bright as a mirror pure copper

is redder than gold. But things can happen to its colour. Is there a copper roof in your village or city? Look at some church, or library, or city hall, a big building. You may find a copper roof. Copper can be hammered or moulded into sheets. And as sheets it is used to cover roofs.

But maybe you cannot tell whether it is copper!

For you should not look for a reddish, copper-coloured roof, but a bright green roof, a regular sea-green one. If it is dry copper stays copper-coloured. But out-of-doors where it is rained upon, copper turns green. A green roof capping a light stone building is beautiful against a blue sky.

Throw some copper scraps, a bit of copper wire will do, into a hot grate fire. Watch the flame turn green.

Copper alone, then, is a red-gold colour, but when dampened or burned it becomes green.

Copper Is Soft

Copper, like gold, is soft. It can be heated and pulled out into wire, so thin you think it will break. But although soft, it is strong and will not break easily. Look at the telegraph and telephone wires. Sometimes they shine in the sun. Did you ever see telephone men unrolling great spools of wire, stringing it up on poles or pushing it through underground conduits? Watch them next time. It is copper wire. Or, better still, if you do not want to wait until new wires are being put up, unfasten the wire ends of an electric plug. Copper wire again! It is one of the best materials to conduct the electric current.

You know yourself that copper is soft. That is why you can work with it in your manual training class. It

bends. You can hammer it into whatever shape you want.

ALLOYS

Pure copper is soft! But, sometimes we want to use it, and have it strong and firm. Then it has to be mixed with something else. When two metals are fused or heated and mixed together the mixture is called an 'alloy'. That just means it is not pure. But like the stiffened copper it may be stronger and much more useful than either metal by itself.

Brass

Copper and zinc fused or melted together make brass. Think of all the things that are made of brass. Look at your brass buttons! Hear that band coming down the street! It is a brass band. Most of its instruments are made of brass. They give out clear, pure notes. Brass is yellower than copper, more like gold in colour.

Bronze

Copper and tin mixed make bronze. Next time you are walking in a park look at some of the statues of great men. They are a dark brown. Touch them. See how smooth they are. They are bronze. Why is bronze used? Because the rains do not change it. We are so used to the word bronze meaning brown colour that we often say 'bronzed by the sun' when we mean tanned.

We really use more brass and bronze than we do pure copper. Think of all the copper, brass, and bronze things you know. Count them. See how many are copper, or brass, or bronze.

HUMAN USES

You know many ways in which we use copper now. You have counted them. But the use of copper is no discovery of ours. It was made into many things long ago.

One day more than eighty years ago, far away in the Central Provinces of India, some shepherd boys were crossing the country with their cattle, probably driving them from one green spot to another. They were crossing a bit of waste land. One boy saw something queer half-buried in the earth. The boys all ran to it. It had a very odd shape. They brought it back to their master. It was a bit of an old copper tool.

The English governor of the area knew that something unusual had been found. So the place where the copper tool was found was set apart to be studied. Men who study about old tools began to dig there. In one place, about three feet long and three feet wide and four feet deep, they found 424 copper tools and weapons and 102 pieces of thin silver plates. They were all of very odd shapes, not like tools used now at all. It was very clear that at one time long ago many things were made of copper. Perhaps this was a storehouse of someone who sold them. Who knows?

How Long Has It Been Used?

The story of the use of copper is very old. You remember we learned that primitive men lived in caves, and that the things that are found in these caves now show how those early people lived? The oldest tools known were made of stone: stone knives and roughly-shaped tools of various kinds. Later men became more skilful and learned about copper. Not only did they

learn to use it but they learned to mix it with zinc to make it stronger. They made so many tools of the two fused together that now we speak of those people as the men of the 'Bronze Age'. So copper has been used for a long, long time.

In India there was a copper statue of Buddha, more than seven feet high. It is now in England. A well-known Chinese traveller in India, Hiyuen-Tsang, says he once saw another great copper statue of Buddha more than eighty feet high, in a small village. From the workmanship he thought it was made about 1,200 years ago. It cannot be found now.

I hope you have your map. Look at Burma. There is a great brass bell there, the second largest bell in use in the world. It is sixteen feet across. It is so deep that if three men stand on one another's shoulders the top man can hardly touch the top of the bell.

So, copper, brass and bronze were used long, long ago.

When the early explorers went up the rivers and across the forests in New York State, and the Atlantic States, and in Canada, they found the Indians had copper ornaments and copper tools. In the east the copper was mainly used in the ornaments. As the explorers went farther west and north they found fewer ornaments and more tools. It seemed that copper was more common. The nearer they came to Michigan and Wisconsin the more it was used for everyday things. After some time they found where the Indians got their copper. It was near Lake Superior in the Keweenaw peninsula. This is still an important centre for the copper supply in North America. This great copper country

stretches north into Canada, and south into Michigan. There is more copper in Michigan than in Canada.

The early explorers even found pits with charcoal and wooden bowls. The Indians broke the copper-bearing rocks by heating them and pouring cold water over the hot rock to make it crack. There were great hammers for pounding it loose.

WHAT AND WHERE IS COPPER

Copper is one of the treasures in the Earth's storehouse. It is stored in many places. Some is found in some soils, not much of it, but it is there. It is found in some mineral waters. It has even been discovered in seaweed. A tiny bit occurs in cheese, eggs, hay, meat and other foodstuffs, especially liver and kidneys. But, of course, none of these is a good place to get it. The amounts are too small.

Most copper is found in rocks. In fact, it is the only metal that occurs free, by itself, in large amounts. You remember when talking of 'igneous' rocks we learned that each mineral has its own shape of crystal. Well, the copper crystal is a cube, the same size up, across and through. It is often flattened, though, and sometimes the crystal edges are not sharp like the cube but are rounded off. But a great deal of copper is not in crystals. Some of it is found woven through the rock like fine threads, twisted in and out of cracks, or in moss-like masses. In some places it is found with silver. Or, it may not be free at all, but united with some other mineral or chemicals, so that it looks quite different. No matter with what it is united, it always burns with a beautiful green colour, or sometimes when cold it has a group of colours, like the 'eye' of a peacock's tail.

How Do We Get It Out?

When copper is free it is easy to get it out. There are some copper mines that do not look like mines at all. The copper is near the surface and the rain and the air have just rotted away the material in which it lies. Because the copper beds are at the surface, the miners just dig away the hillside. A lot of the copper occurs like this in Arizona and Utah. There is a big copper mine in the hillside at Salt Lake City, all above ground. Of course, there are some other impurities in it that have to be separated from it.

When copper is bound up tightly with some other metals or minerals it is another story. It has to be 'smelted'. That means a lot of things have to be done to it to break it out from the rock and to make it clean, pure copper, so that it can be used. There are three ways of cleaning it: the 'dry' way, the 'wet' way, and by electricity.

The 'dry' way is used for rock that has a lot of copper in it. It is roasted, usually with coke. And some of the impurities are separated from it. But not all, not iron. Then it is mixed with some other things. This is chemistry again. When you are old enough to study chemistry, you will learn what these other things are. However, when it is all melted the iron that has been tightly bound up with the copper leaves it, and joins the other mixture. So the copper can be taken off purer still. It is nearly pure now, but not quite. It is white, at this stage, called 'white metal'. It is roasted again and other impurities run off. Now the copper is pure!

Different kinds of roasting furnaces are used in different countries. Some of them are shaken so that the

heavier minerals will drop more quickly to the bottom. Some of them are made hotter by blowing or 'blasting'. But whichever kind of furnace is used the copper is made pure by the roasting.

Then there is the 'wet' way. It is used for rock which does not have much copper. It is really chemistry and a little hard to understand yet. The rock is crushed and put into a mixture that dissolves it. Do you remember salt will just drop from the water in a glass when the water can hold no more? Well, water, or any other liquid, can hold some things longer than others. So all the metals that drop out first, before the copper, are taken away. When the copper drops out, it is like a salt, too, and still has a few other minerals with it. Then the copper salt can be put into another liquid, and the copper made to drop out, pure.

And then there is the electric way. That is perhaps still harder to understand. But an electric current is sent through the mixed-up coppery mass. It separates the other minerals from the copper. The electric current is really the easiest way. Men knew about it for a long time. At first they could not make a current strong enough. Then somebody invented the great dynamo. And presto! There was a strong current! Next time you are near a power-house go in, if they will let you, and look at the dynamo. You will not be able to see how it works, but you can see what it looks like.

You remember gold and silver are mixed with copper in some rocks. The gold and silver are also separated out by the electric current, and saved, so that such copper-bearing rock is doubly valuable.

Where Found?

Fortunately copper is found in a great many places in the world. In Europe it is found in England, Spain, Portugal, Germany. In England it is found in Cornwall near the great tin mines. So the Cornish people learned early to mix it with tin and make bronze. It is found in South Australia. In Asia it is found in Siberia and Japan. In South America, it is found in Chile and Peru. A great deal of it is found in Africa. In North America it is mined in Mexico, United States and Canada. The largest copper mines of pure copper, as we have learned, are around Lake Superior.

So the next time you work with copper in your manual training class, or see one of those green copper roofs, remember that it is one of the treasures stored in the Earth.

CHAPTER III

TIN



TIN IN OUR LIVES!

That Old Tin Can!

PICK IT OFF THE ROAD, that old tin can. It may cut somebody's motor tire. How did it get there? It must have fallen from a garbage wagon. Poor, forlorn, deserted, tin can, full of holes! Once it stood in a soldier-like row with other tins, all the same size, all the same shape, all having the same picture on their rounded sides. Tinned peaches on the shelf of a grocery store! And the tin pails we use—for holding dew worms, or for carrying water—until the holes appear! First there is a rust spot, then a hole!

Now tin does not rust. And yet a tin pail will have holes. The reason is your pail and the tin can are not

really tin. They are iron with only a thin coating of tin. The tin wears off. The iron rusts through.

Once tin pails were really tin pails. We just never changed our habit of calling them so.

But pails of pure tin would be very expensive, and too heavy. Steel is much lighter. But steel, like iron, rusts unless specially treated. Someone got the bright idea of covering the steel with tin, so that dampness would not reach it, and then it would not rust. But we still call them tin pails and tin cans. And when the tin wears off they still rust.

How to Make Tin Cans

Bars of mild steel are cut the length wanted, heated and rolled between heavy rollers into thin sheets. The sheets are doubled over, heated again, rolled and doubled again. This is done several times. Then they are pulled apart, rolled out when they are cold, and smoothed and trimmed. They are made hard by plunging into cold water while still hot. Then the sheets are cleaned with weak acid. The thin clean sheets are just dipped into melted tin, a thin coating of which sticks to them. They are then passed through an oil bath. When they have been cleaned again after all this, behold! A smooth bright sheet which looks like tin, but which is much lighter in weight. The tinned sheet is then ready for making into cans or pails or whatever is needed.

Tin-foil

In a candy shop you look for chocolates. Chocolates are good! If they are fresh they are good, but not so good if they are dry. But those wrapped in tin-foil over there will be fresh and good!

Why are they wrapped in tin-foil? To keep the air

out, so the candies won't get dry. A lot of things are wrapped in tin-foil to keep them fresh. You often see them, I am sure.

What is tin-foil? It is just tin hammered out very, very thin. In China a great many children work hard year after year hammering tin into paper-thin sheets. In Europe and America machinery is used. And—can you believe it? one pound of tin can be rolled so thin it will cover 18,000 square inches. Aluminum can be rolled to cover twice that area.

Sandy Through the Looking-glass

Sandy breaks his mirror. Let us look at it. We can really see what a mirror is like. It is glass on one side, isn't it? What is on the other side? This is an old mirror, for that something on the other side is a mixture of tin and mercury or quicksilver.

Mirrors with a mercury-tin mixture on the back have been known for some hundreds of years, since the time in history that men call the 'Middle Ages'. About a hundred years ago, though, another way of making mirrors was invented. Silver was put on the back. Silver is generally used now because it is easier to make and lighter in weight. But the backing of tin and mercury really lasts longer. It does not 'fog' so quickly, and it sticks to the glass better.

That Tea-kettle Again!

And then there is your tea-kettle. Of course there are several kinds of tea-kettles. I hope yours is one of the best. Perhaps it is a little worn on the curves at the top. What is that you can see where the tin is worn off? It is copper! Tin is used to cover copper. Copper has some quality which makes it easy for other metals to adhere

to it. A great many pots and pans and other everyday things are made in that way. There are not quite so many as in your grandmother's time, because now chromium is often used instead of copper. Chromium is generally kept, however, for more expensive things, like the shiny parts of motor cars.

Copper does not rust, so tin over copper does not rust. But it is not so cheap as tin over iron.

And then, in addition to the tin-covered copper you remember there is a mixture of tin and copper that is called 'bronze', known for hundreds of years. It is still one of the most important metals for parts of machinery where two metal surfaces rub. Thousands of tons are used in the big guns, in recoil slides and in marine engines to reduce friction.

Jingle Bells

Have you heard the bells of the Peace Tower in Ottawa, or of the singing tower in Florida? Or if not, just listen to the church bells some frosty morning. Think of the clear note of a beautiful bell. We often say the 'silver tone of bells'. But tin, too, is used in bells.

In Your Great-Grandmother's Kitchen

Is there pewter in your house? If you live in the New England States, I will wager there is. Nowadays people collect old pewter dishes. Modern pewter is often smooth and highly polished. It is very beautiful. The colour of pewter is quite like silver but just a little darker, not quite so cold-looking. In former days pewter was often made into very ornamental pitchers and vases, candlesticks, and many other useful things. It was used every day, much more so than now—pewter bowls, pewter spoons, pewter plates.

What is pewter? It is tin mixed with lead and some other metals.

WHAT IS TIN?

Common tin, bright and beautiful, and so useful! What is it?

Well, you certainly know its colour. You have seen it often enough; light-coloured and shining. It does not rust like iron. It can be made into sheets, so thin you can crush them in your hand. Like copper it is so soft it has to be mixed with something else to stiffen it. It may be used as a thin covering over something firm.

Tin is one of the treasures of the Earth's storehouse.

Where Does It Hide?

In some places native tin and tin oxides occur like grains in tiny cracks in rocks that have once been melted. Sometimes it is found in veins of rock. Do you remember we also find gold in veins? In Bolivia tin is found with silver, and other valuable minerals and metals. Tin, like gold, is found in 'placer' deposits. In places on the Earth great quantities of it are found in dark lumps called 'tinstone', or in some cases as beautifully marked polished pebbles in gravels along streambeds. Like gold it became part of the gravel, because, with the stones of the gravel, it too was once part of the 'bedrock' from which the stones were broken off. It just moved along with the other stones and was ground and worn into smaller and smaller bits.

Bolivia, in South America, and Banka Island in the East Indies have most of the tin trade of the world, or did have it before World War Two. But they did not always have it.

Tin of the Ancients

You remember the ancient men of the Bronze Age? We learned that bronze is made of tin and copper. But not all the bronze of the ancients was made of these metals. Tin is mentioned in the Bible, but it is not really tin. It is a mixture of copper and something else. This mixture, which is called tin and is not, was known in Egypt 1,600 years before Christ, and that is more than 3,000 years ago.

You learned in your history that long ago the Phoenicians came across from the eastern Mediterranean, sailing around Spain and up the west of France, to the south of England for tin.

Long after the Phoenicians the Romans came to England. They found tin and used it. The Romans had very tidy minds. They wrote things down. We know from their writings they did not know all the differences between tin and lead at first. They knew, of course, one was heavier than the other, and that the tin was whiter than the lead. So they called the tin 'white lead'. By the time Julius Caesar came over and conquered parts of the island the Romans began to find large quantities of tin in Cornwall and Devon. And during the first century after Christ they began to carry it away in their ships.

Tin has been taken from Cornwall and Devon for hundreds and hundreds of years. There is a long human history of the tin-mining in Cornwall; the struggles the miners had; the trade routes that tin travelled in the early, early days; the way the miners fought for their rights; the part played by the Duchy of Cornwall; the money that came from it; the huge amounts of tin that

were sold out of England—a long, long history! There is not time to tell it here.

The Romans took away all the tin they could. After more than four hundred years the Romans had to leave Britain. And then the British themselves began to take out tin, and kept taking it out. At first they took it from the surface. Then they dug deeper into the gravels. It was loose, dirt-covered tinstone. It was just dug out with a pick and shovel, and the dirt washed from it in a trough of water. The ground surface of the whole region was soon full of trenches and holes as more and more tin was dug out. The trenches filled with water, and had to be drained out.

The miners dug deeper to drain off the water. This all meant labour. They had to find better ways of getting the tin out from the sides of the holes. At first there was no system or order. Everybody just took what he thought he had a right to take. The whole place got into a horrible mess of trenches and holes.

By the time Cornwall and Devon had been mined in these irregular ways for hundreds of years, all the loose tin was gone. But miners worked back and back, and down and down, and at last found the parent rock from which the tinstone had been broken off. Now they are mining, not loose gravels, but the rock from which the gravels were made.

How Is Tin Separated from the Rock?

When the tin is taken loose from the gravels it is washed. The lighter clays, sand and stones are carried away. But when it is in hard rock it is a different question.

Like the copper it must be broken out of the solid

rock, brought out of the deep tunnels of the mines and then ground to a powder, and put through sieves in a trough of water. Then it, too, is roasted, usually in a vibrating furnace to separate the tin from the impurities. In some countries where charcoal is cheap, they use a furnace like a long shaft. A layer of charcoal and then a layer of tinstone is put in, then another of charcoal followed by another of tinstone, and so on. When it is filled, fire is started at the bottom, and a big blast of air is sent through the fire from below. It burns up with a great heat, melting the tinstone. The charcoal burns with the oxygen from the tinstone and then the pure tin runs out at the bottom. In England and in many other places coal is used for the furnaces.

After all this the tin is much purer, but not absolutely pure. It is then melted, very carefully. The tin melts quickly and is run off. Then it is 'poled', that is, stirred so that the purest tin rises to the top of the vat, like a froth. It is skimmed and poured into moulds, making long bars. Long, long ago, the tin was 'poled' by using a branch from an apple tree. So for years and years, it was thought that an apple branch was the only 'pole' to use. A tree branch is no longer used, but stirring the boiling tin is still called 'poling'.

Now we have some very pure tin. It must be tested. The bars are heated again, not very hot, but enough almost to melt them. Then they are struck by hammers. If the tin falls to the stone floor, splitting into a mass of grainy strings, then the tin is pure.

Where Is the Tin of the Earth Stored?

You know about England, and about Bolivia. Did you ever hear of Banka Island? You need your map. Turn

to the south of Asia, and just east of Sumatra, not far from Malay peninsula, you will find Banka Island. It holds the purest tin in the world. There is tin along the Straits Settlements, and in Australia. In Europe, besides England, it is found in Saxony, and in Bohemia.

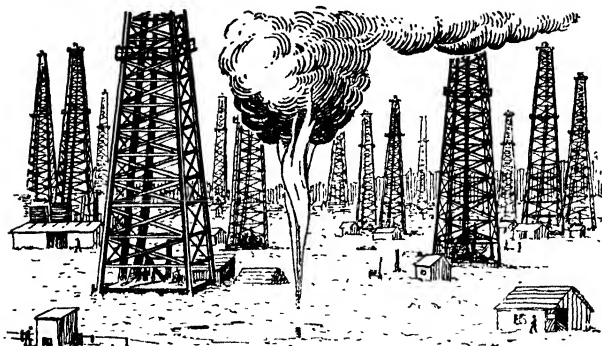
Very little tin has been found in North America, not enough to be worth mining. The great quantity used in the United States and Canada is brought from other countries.

* * *

And so tin is one of the treasures of the Earth, kept in its storehouse until men want it enough to get it out and to find how to use it.

CHAPTER IV

OIL AND GAS



ANOTHER PAIR of twins! No, two branches of an immense Family, closely related! Oil is a large Family all by itself that sees the whole world in the travels of its various members. Gas is a Family, not so large, more of a stay-at-home, but very useful!

"Ho!" I hear you laugh, scornfully, "gas travels all over the world in motor cars and bombers, and mosquito planes, flying fortresses, etc., etc."

Not so fast! That is not gas. That is gasoline, just 'gas' for short. And gasoline belongs to the Oil Family, not to the Gas Family. Real gas travels in pipes and can go only as far as the pipes carry it.

The Oil Family is very large. I do not suppose there is a boy or girl that has not met some of the Family.

WHAT IS OIL?

There is gasoline—a very familiar friend. It makes your car run. It is used for aeroplanes. When mixed with air and made into a vapour it is exploded by an electric spark. That explosion is called 'combustion'. It moves a piston which moves something else and so on. Such engines are called combustion engines, and gasoline is used for many of them. Farms use them for pumping water. Your mother or sister use gasoline for cleaning clothes. If they do not, then the Dry Cleaners do.

When you go away for the summer to a northern lake or a river, gasoline 'putt-putts' make the night hideous, racing around going nowhere. Or, do you like their noise?

Perhaps you go out to a farm for the summer. After you leave the main line you go on a little train, with a funny little chug-chug engine, a Diesel engine. The fuel of that engine is oil, not very heavy oil but still a member of the Family.

If you live on a farm, you know that in the spring the farmer sat behind the tractor to do his ploughing, and together he and the tractor drove around the field like a great insect, hither and yon, but in an orderly way. And the ploughing! It was done in a trice! The tractor is run by a member of the Oil Family.

Perhaps some of you have been on a great ship at sea, or even you may have seen a long greyhound lying quietly in a harbour, a battleship! Not many years ago ships were run by coal-heated steam. Now, the fuel used is a member of the Oil Family.

Once I was on a ship in the Caribbean Sea, just off

Trinidad, and a 'tanker'—a ship bringing oil—came up alongside. She looked like a huge whale, rounded on top so the waves could roll over her, except for a central 'poop' which rose above the whale-back. Three or four great, thick hose-like pipes came over our side, each was fastened to a permanent pipe on our deck, and oil was pumped in, right at sea. One careless little midshipman forgot to turn off a cock at the right time, and oil poured over the deck. The captain was angry, but I saw the oil, heavy, dark, greasy stuff. You would hardly think it belonged to the same Family as gasoline. But it does.

All these oils we have been talking about belong to one branch of the Oil Family—Fuel oils. You know most of them. It may be that you have an oil furnace in your house.

Do you have to mow the lawn on Saturdays in June when Saturdays are precious and grass grows quickly? The lawn-mower is heavy. You oil it, perhaps with your mother's sewing-machine oil.

After you have driven your car some hundreds of miles you take it to be greased. And watch, if you can, a locomotive engineer grease his shining engine. If your bedroom door squeaks, you oil it. These oils that make machinery run smoothly are called 'lubricants'. In some cases they are a thick sticky grease—like vaseline, and vaseline is one of them—members of the Oil Family, all of them.

Ask your grandparents if they went to bed in the dark. They did not have electricity then. What did they use for light? Oil lamps! Kerosene! At first it was distilled from coal and called 'coal-oil'. Later when made

from natural oil it was still called coal-oil in parts of the country, and kerosene elsewhere. Even now when I go out on 'field work' at some farmhouses I go to the kitchen for a lamp.

What is a lamp? A bowl-like base filled with oil, in it a wick which passes up through a slit and is lighted at the upper end. The wick soaks up the oil which burns brightly and steadily as long as there is oil in the bowl.

When you are sunburned you put on cold cream. You use oil in medicines, in mosquito and moth sprays, in paints and varnishes, or any number of common ways. All are members of the Great Oil Family. Mineral oils they are sometimes called.

Did I hear someone say something about salad oil, olive oil, oil of roses, peppermint oil? Yes, these are all oils. But they belong to another branch of the Family. They are pleasant things. We like them for their flavour or their fragrance. They are vegetable oils.

Have you that 'tired feeling', or are you too thin? Then along comes someone, friend or foe, and suggests or insists that you take cod-liver oil. They may dress it up as an emulsion, or make it into a pill, but it is cod-liver oil, and not very nice or it would not have to be disguised.

But codfish are not the only oil producers in the sea. Whale oil kills rose worms. I don't wonder! Did you ever smell it? Eskimos use whale oil for lights and whale blubber to eat. These, too, belong to a third branch of the Great Oil Family. They are animal oils.

I have left out quite a number of the many cousins

of the Family. But enough have been mentioned for you to think up some more yourself.

WHAT USE IS GAS?

The Gas branch of the Family is something of a Martha in the household. It stays at home and does the cooking or the lighting. But there are two sub-branches of the Gas group.

There is 'artificial' gas, that is, gas that is made. It is not really 'made'. It is taken from coal. There is a 'gas works' on the edge of most cities, where it is made and piped up and down all the streets and into houses. A generation or two ago it was used for street lights.

Did your grandfather live in a city when a boy? I will tell you one thing he saw. When darkness began to fall, down the street came a man with a pole. He stopped at a street lamp—you see they still called them lamps—poked the pole up and by means of a little clip he turned a cock just below the jet. Out came the gas. You could not see it. But right on top of his pole was a little lighter. He touched the light to the jet and the light flashed on. The gas had caught fire. He went on to the next lamp standard. A trail of light followed him down the street.

Now, however, away off in an electric power-house, some unseen, unknown person throws a switch and all the lights pop out at once up and down the street.

But we still use gas in some houses for lighting, and for stoves, though it, too, has been largely replaced by electricity.

The house gas is artificial in most places. It is generally expensive because it has to be taken from the coal. But there are places in the world, and in North

America, where ready-made gas comes right out of the ground. It is piped far and near. It may be used just like the 'made' gas for lighting and heating. And it is much, much cheaper in the places where it can be obtained.

These gases are really not so different from one another as they seem at first.

But gas, natural gas, does something else. It is almost like a Cinderella, in this, instead of a Martha. The Oil branches of the Family when ready for use, wander far and wide over the face of the Earth, over the oceans and up in the air, but the gas, poor Cinderella, helps to make them ready. It helps to bring the oil from the ground. Read on and you will see how. And when the oil is out of the ground, gas helps to separate the light and heavy oils and sends them out to places where it itself can never go.

THE GREAT TRIBE OR FAMILY

Now this great Tribe or Family with many branches in the Oil Family, and the not so many in the Gas Family, has a name—Hydrocarbon. The name means it is made of hydrogen and carbon.

Did you burn your toast this morning? That black you scraped off was carbon. Coal is mostly carbon, and so is charcoal. So is sugar, strangely enough! Burn some. See the same black stuff. Hydrogen is a gas. Water is hydrogen and oxygen. You will have some experiments with both when you study chemistry.

All living things must have carbon. When any plant or animal dies some form of carbon is left. So our great Tribe or Family of Hydrocarbons must have had something to do with life. And they had, all of them, somewhere, some time, so men believe.

That whale oil and cod-liver oil are connected with life you see at once. It was made from food by the processes of life of the whale and the codfish. The salad oil, olive oil, oil of roses and all the rest are simple, too, at least comparatively simple. They were made during the processes of life of the plants from which they came, made by the food the plants took from the air and the soil.

But the Oil and the Gas in the Earth, from where did they come? What had they to do with life? We get them from the rocks deep in the Earth. They are not rock, even though the Oil is called mineral oil.

Fill a dish with sand. Pour water over it. Quite a lot of water can be poured in without making the dish any fuller. The water fills in the tiny spaces between the sand grains.

And oil-bearing and gas-bearing rocks must be porous, either a sandstone or a rock filled with pores and cracks.

But if life produced oil and gas, how did they get in the rock? I think you begin to see. There are rocks that were melted—oil is not in these rocks—and, there are rocks that were laid in the sea. And in the sea was life, plant life and animal life. And as each form died it fell to the bottom and was entombed, some of the hard parts to become fossils, but the soft parts to decompose and scatter far and wide. That, most men think, is the real source of the Oil Family, the part of it found in the Earth.

All of them from life!

HOW OLD ARE THE ROCKS?

If Oil and Gas come from life then they are most abundant in rocks that were deposited after life had developed abundantly.

Oil and Gas do occur in pockets but not in abundance in the rocks laid at the beginning of Page Two. Sometimes where these rocks lie beneath the soil a boy or a farmer will find little iridescent streaks of oil flowing out with water from a spring, and he may think, "I have found oil." But, as I said, in these earlier sea-laid rocks oil is in disconnected pockets only. And, to be of use, large reservoirs are needed, not just pockets of it.

But later on Page Two, you remember, the living things began to spread, and plants increased, even seaweeds, just before the great development of fishes. It is in the rocks laid at that time that we begin to find oil and gas in any quantity, and more of them in rocks laid when the fishes multiplied, and abundance of them in many rocks that came later.

COVER NEEDED

Pour oil on water. It floats on top of the water! Look at a canal if you live near one. The oil from the boats spreads over the top of the water. Try some in a glass of water. Oil, then, is lighter than water.

And gas is even lighter still. Not only does it float on water. It floats on air, and scatters far and wide. We say it disperses.

What happens when you open a ginger ale bottle? The gas within froths to the top and scatters. It was put there under pressure and the top fastened on securely. Gas, 'natural gas', is lighter than air. It has been down in those rocks for millions of years. If there were

cracks or crannies it would have dispersed long ago. The rocks containing the gas there, must have been covered to keep it in.

And oil?

A pail of water stands on the floor. The bottom of a curtain trails into it. When you go back to pick up the pail the water has crept up the curtain. If you are away a long time, leaving the curtain trailing in the water, you will find the pail empty and the curtain dry. What happens? The water creeps up the curtain and evaporates or is taken into the air. "Dries up," we say.

And that is exactly what happens to the oil if there is a way out for it. It creeps up and up the tiny spaces in porous rocks and passes off. Little by little it goes. And, remember, some of this oil was made millions of years ago. There has been a long time for it to creep up, little by little.

And so oil-bearing rocks must be covered.

WHAT MAKES A COVER?

Thick solid formations of limestone will form a cover over the porous oil-bearing rocks. But better still, an excellent cover is a thick bed of shale. Shale is very fine, and has few cracks. There are few or no pores for the oil to creep through.

So the porous oil-bearing sediments must be sealed over by an impervious bed, that is, one which cannot be penetrated by the oil.

So far so good! The porous oil-bearing beds are sealed. The oils and gas cannot get out.

BURIED RIDGES

The best place to find large reservoirs of oil is on the sides of buried ridges. You must have the oil-bear-

ing rocks and the capping rocks just the same. Now think of those rocks lying sloping up the sides of a buried ridge.

Oil is lighter than water so it will float up the slope above the water. Gas is lighter than oil. So it will float up above the oil.

Why must the ridge be buried? Because if uncovered the oil and gas will escape out from the edges.

I said the best place to find oil and gas is along a buried ridge—and buried ridges are the best. But both are found in more or less flat-lying basins. So much of the world's oil and gas have been taken from the buried ridges that the large oil companies are now exploring in the flatter basins.

But you can see for yourself that the oil won't run together in a reservoir so well in a flat area as in a sloping one.

AN OIL FIELD

When it is suspected that an area holds oil, test wells are drilled. When an oil field is assured, roads are built, a water supply secured, and then the drilling starts.

Some of you, I know, live in an oil country and know the derricks that dot the land. There are several types of machines used. First the hole must be drilled down to the beds bearing the oil. The drill is driven down and down. The bit at the end of the drill chews up the rock. Water often comes into the hole through the cracks at the sides. When enough rock has been crushed fine the bailer is put down to take it up. As the material, the chewed-up rock and water, comes up it is examined to see what rock is being drilled through, limestone, shale or sandstone, or any other type or combination. Notes

are kept, and some of the drillings. For often there are tiny microscopic fossils in them. If the geologist (for practically all oil companies have geologists now) learns the order in which the beds lie on top of one another, or how many beds the drill has passed through before oil is reached he can tell better how many feet in depth it will be necessary to drill for the next well in the field. So he or the driller keeps a careful account—a 'log'.

Suddenly the bailer line is slackened. Something is pushing it up! The cover has been pierced through to the gas and oil-bearing rock.

Maybe it is a gusher! Hold on to those tools! It may shoot them up. Careful does it! The top is off the great ginger ale bottle!

WHAT MAKES IT POP?

Gas and oil, you know now, are lighter than water. Perhaps the water is pressing up from below.

"But, water," you say, "hurries down, not up." It does.

Around the circumference of almost every oil field is water, a catchment basin of rain water. It may be that the ground water of the region is higher than the water below the oil and that it has access to it. This water is pressing hard to get down. All its weight presses down. It is stopped by the water beneath the oil. And the water beneath the oil presses upward against the oil with all the force with which it is pressed by the surrounding water. The drill has pierced the covering rock. The gas and oil have an outlet and up they come, driven by the pressure of the water beneath, which in its turn

is driven by the weight of the water from the surrounding slopes far and near.

GAS AT WORK

There is another reason, for the spouting of the gas and oil.

When the 'lid is on' over the oil and gas, the gas is dissolved in the oil under pressure, just like the gas in the ginger ale bottle. If there is more gas than the oil will dissolve it remains free gas at the top. When the hole is drilled and the gas released, up it spouts, first the free gas, if any, then the gas and oil.

Danger Ahead!

But there are dangers! Let it alone! Up it comes! The oil mixed with gas is more fluid. If allowed to flow according to its own sweet will, the gas from the oil far below will work its way to the top and leave the oil behind to take care of itself. The oil alone is heavy and slow. It will not flow easily. It sticks between the sand grains or whatever pores it is in. It is lost!

So, do not let it flow too freely. Keep some gas with the oil.

Rumours and More Rumours

So sometimes you hear that the oil companies or governments are holding back or cutting oil production. The oil companies will do anything within the law, to make more money. But that is not always the reason. The big operators and governments have learned that a controlled flow will bring up more oil in the long run.

Crude Oil

'Crude oil' is what we call unrefined oil. You know it, dark and greasy and usually fairly thick. That crude oil

is made up of a number of things, the heavier elements dissolved in the lighter.

There are two main types of oil. Some have a paraffin base and some have an asphalt base. You know what paraffin is. Think of the top of your mother's jelly glasses, or of a candle. You know what asphalt is. Think of an asphalt pavement, or the pot that boils and smokes on the street when the man mends your roof.

Hold up a glass of crude oil. What is it?

Do you live near a lake or the sea? Watch two waves rolling by. You can see two crests and the trough between. But can you tell just where in the trough one wave ends and the other begins? So with the mixture of oil and oil.

'CRACK' IT!

The oil has to be separated. Remember the heavy oil is dissolved in the lighter. Not easy to separate!

It is 'cracked'. It all has to do with molecules and atoms and such things—mysterious things about which you will learn later. The molecule of oil is made up of a group of elements, just as water is made up of hydrogen and oxygen. When the crude oil is heated under pressure the molecules will crack apart and re-sort themselves, so you can get oils of paraffin base and oils of an asphalt base and separate them. Some of the gases also will come out.

REFINING OIL

There are various ways of refining the oil. The old way was to heat a great 'shell' and draw off the vapours at the top. The vapours were cooled and the lighter oil which was in the vapour condensed. But not now.

We want many kinds of oil and gas. Aeroplanes need lighter 'gases' than motor cars, and both oils are much lighter than the oil you burn in your furnace or than is burned by the Diesel engine, or by the engines of the great ships at sea.

So the present refiners are very complicated. Far too complicated to tell about here.

But there is a general plan. All the oil is heated until it becomes vapour, and heated by the Cinderella 'gas'. Now, some oils cool to liquid from vapour at one temperature, other oils at a higher temperature. You know that. To melt asphalt requires quite a lot of heat. But melt some paraffin for your mother's jelly glass. It melts with just the slightest heat. So by heating into a vapour and cooling again at several temperatures it is possible gradually to gather together in one stream all the vapour oil that becomes liquid at a very high temperature. As the vapour becomes still cooler another oil will become liquid, and so on.

HISTORY OF THE USE OF OIL

The use of oil is older than written history.

Asphalt was used by men long, long ago. It was called by different names down through the ages. Now, even, we call it pitch, tar, bitumen or asphalt. Gas seepages lighted by accident such as lightning were worshipped by some.

Read in your Bible about Abraham who came from Ur of the Chaldees. They were using asphalt as mortar for bricks there. In building the tower of Babel 'slime' had they for mortar, and the 'slime' was asphalt. It was used in Nineveh. Search the Scriptures to see how Nebuchadnezzar used bricks and bitumen. All these

people lived near Mesopotamia or Irak, still one of the great oil sources of the world—a scene of struggle in both Great War One and Great War Two. Both Germany and the United Nations wanted that supply.

Herodotus, about 450 B.C. tells about oil from pits in Persia.

WHERE ?

Asia

Asia has many oil and asphalt fields. Irak has already been mentioned. In the Sinai Peninsula Moses after he fled from Egypt tended the flocks of Jethro and the “angel of the Lord appeared unto him in a flame of fire out of the midst of a bush, and he looked, and behold, the bush burned with fire, and the bush was not consumed.” It was a gas seepage.

On the island of Bahrein in the Persian Gulf and around its shores oil is found. In Burma there is oil “on the way to Mandalay”.

One of the great oil fields of the world is in the Dutch East Indies. The Japanese grabbed those oil fields in the first wild onslaught of World War Two. There is oil for the lamps of China.

Europe

The oil fields of Baku in southern Russia near the Caucasian Mountains have appeared in history down the centuries and were again the object of a great campaign in World War Two. Every boy and girl knows or ought to know of the battle of Stalingrad. Why were the Germans so determined to break through? Why were the Russians even more determined that they should not? The oil wells and asphalt deposits of the

Caucasians and particularly at Baku on the Caspian Sea—this was the goal.

The Magi or three Wise Men who came to Bethlehem were Fire-worshippers. They came from the east, from Persia, the centre of Fire-worshippers and astrologers, those who think they can foretell life by the stars. And the principal temple of the Fire-worshippers was near Baku where a fire, a gas seepage, forever burned. It was a place of pilgrimage. It still is a place of pilgrimage, not now by Fire-worshippers but by oil worshippers. It still is one of the world's great sources of supply.

Oil and asphalt is found in other places around the Caspian Sea. Russia is the world's second largest producer of oil. When it is all explored it may become the first.

Over in Rumania, too, are the same rocks as those around the Caspian Sea, all deposited by a sea that extended far inland over Europe. And in Rumania, too, those rocks have oil. In World War Two as in World War One these oil fields were the desire of Germany.

Africa

Little is known of the oil of Africa. Most of Africa has not been explored for oil. Egypt we know for centuries used oil and asphalt but probably got it from the Sinai Peninsula and the Dead Sea in Palestine.

South America

One day in March I stood at the bow of a large boat on the Pacific Ocean as we slowly drew in to the most westerly point of the mainland of South America. It was Talara in Peru. The top of the cliffs on shore were

studded with derricks. And believe it or not! The ocean was studded with them too! Out from the shore! For the oil-bearing rocks extended out under the sea. Talara is in Peru. And Peru was one of the first oil-producing countries of the Western World.

Colombia, Venezuela and Trinidad are also oil producers.

Trinidad is known all over the world for its Pitch Lake, an asphalt lake. I have walked across it, and watched the men dig a hole in the pitch, throwing it into little dumping cars like those used down in the gold mines. The little cars go rattling down to the wharf where the pitch is unloaded onto ships and carried north to make many a pavement in the United States, Canada, England and other parts of the world.

The holes dug by the men are about two or three feet deep. As the workers move across the surface of the lake the holes behind them slowly fill. Inch by inch the asphalt flows in from the sides, and in places the pitch oozes up from below. To walk across it is like walking on an asphalt pavement softened by the sun.

The lake is really very small. We would probably call it a large pond if it were water.

Canada

Canada has a few oil fields. Western Ontario has produced oil and gas slowly but steadily for many years. The Turner Valley fields in the foothills of Alberta have produced considerable oil, and quantities of gas, much of which has been wasted.

You have all heard of the Canol Oil project, where oil from Fort Norman on the Mackenzie River has

been piped in and out the mountains and over the passes up to Alaska.

The tar sands of Alberta hold a considerable quantity of oil, but it is so costly to extract the oil from the sand that this source has proved disappointing at present.

Mexico

Before Cortez "stood on a peak in Darien" asphalt and oil were found in Mexico and used by the Aztec Indians. Mexico has written a new chapter in the history of oil. The Mexican Government took over the oil fields and all the foreign companies from the United States and Great Britain had to move out.

United States

The United States is the leading oil-producing country in the world. It must look to its laurels though, when Russia gets in full swing.

Like the colonization of the country the discovery of oil moved westward. First it was discovered along the Appalachian Mountains. Then it was found in Pennsylvania, Colorado, Wyoming, California, and so on. In twenty States there are important oil fields, besides some smaller ones in other States. The State of Texas is the greatest oil field in the world, to date.

CONCLUSION

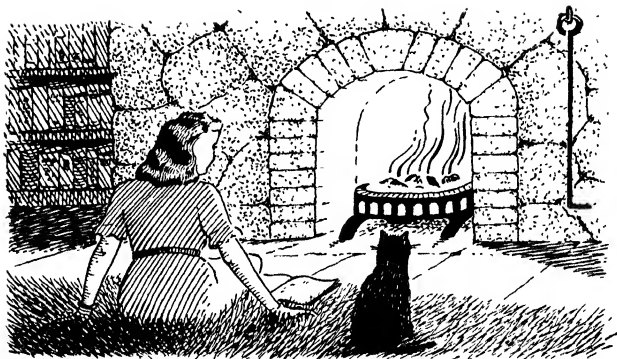
Shut your eyes and think of those oil derricks stalking across the land!

Then think of Russia, Irak and all the other places. Think of all the oil in the world that is being drawn up from the Earth!

The Earth a Treasure House! Surely!

CHAPTER V

COAL



SUNDAY MORNING, bright sunshine, sleigh bells, three bright-faced children behind warm furry rugs with their father and mother. Snow piled high on either side of the road! Have you ever driven thus? Clear crisp air against your cheeks, and brilliant sunshine overhead, and over fences, and field on field deep in snow! Shadows of the pine trees and fence posts blocked in deep blue!

The sleigh turns in a gateway flanked by piles of snow. The dog rushes out to welcome them. Children and dog chase one another and tumble in the clean white snow.

It is cold, well below zero, cold but beautiful!

Then the family goes in. Standing quietly in a corner

of the living-room is a stove. Its heat embraces them like the welcome of a friend. Its glowing eyes invite them. It burns on steadily day and night, for this is a coal stove. In the front above the bed of coals is a door, and in the door are set pieces of mica through which the glowing coals look out cheerfully.

Coal stoves are still used in parts of the country where furnaces have not invaded and where wood is scarce.

If you have not been fortunate enough to be welcomed by a glowing coal stove, you have stood on a station platform and watched a great monster of an engine approach. You are thrilled with the thought that it is bringing someone to you, or perhaps is going to carry you away, away, somewhere! But just take time to look at the big black car behind the engine, filled with coal. This coal is not primarily for heat, though it produces heat. The heat is for power. The coal heats the engine boiler. The water in the boiler becomes steam. The steam expands and pushes the pistons—and there she goes!

THE HYDROCARBON FAMILY AGAIN

Coal is another member of the Hydrocarbon Family or Tribe. It is carbon, hydrogen, oxygen and nitrogen—that is, when it is pure coal. And it never is. But that is the basis of it. It is again that mysterious uniting of atoms into molecules of which you will learn something in chemistry.

You remember when reading of Oil and Gas that hydrocarbons had their origin in life. And there you are again. Coal was living vegetation.

But, sad to say, coal is not all coal.

Ash

After you have burned your fire you must clear away the ashes even if it is only a little grate fire. What is the ash?

In plants there are minerals that will not burn. Plants take up iron and potash and other things from the soil. You poke a white tablet into the pot of a weak plant to make it grow. It contains some mineral parts. And the plant just gobbles them up and grows strong. Many of these minerals will not burn, and sulphur in various forms is one of the most difficult impurities.

But probably most of the ash is carried in by water or blown in by wind when the coal was being formed. Ash material may even be blown into the coal after it is mined if it stands waiting to be delivered to you.

Water

You can easily see how water could be in the coal. It grew in moist places, and any amount might seep in through the ages.

But water does not make ash! No, but it has to be driven out, and some of the heat is used to drive out the water, which is not so good! It is poor coal that has much water.

Gas

Do you live in the northern States or in Canada? If you do you probably know the irritating ways of a coal furnace.

"Open up the damper, the gas is filling the house!" calls someone, just when you are in the middle of a most interesting book, or ready to fall asleep at night. The gas has escaped without burning, and instead of going up the chimney and dispersing in the upper air,

it has come through the furnace door and the open damper and is seeping through the house. And that gas is poisonous. Fortunately, there is an evil-smelling sulphurous gas with it. It is well it is evil-smelling. The danger can be detected.

If you do not live where coal furnaces are used you know the gas from the engine of a train. It is the same—coal gas.

And then you remember the lighting and cooking gas, 'artificial' gas, so-called. It, too, was taken from coal.

Thereby Hangs a Tail

"The tail may wag the dog." The part that was unimportant, the waste, a mere by-product, is becoming most important.

Something like that is happening to the making of gas from coal, when the gas is taken out and coke is left. The gas is used and the coke is used. The coke can still be burned for heat or cooking. It burns up faster than anthracite coal but it is very good.

The coke and gas are the dog, in the process of making gas. But there is a gummy stuff left, sticky, ugly, dark—that is the tail. The dog was the thing! The tail was no particular use—just waste! But it is no longer so. For in that gum were many precious things. Chemists treated it this way and that. They cooked it, boiled it, put this into it, took that out of it. Now it is known to be the source of hundreds of valuable things, benzene for instance, aspirin, plastics. See if you can find twenty things made from coal-tar, for that is what the 'tail' is called. Perhaps the tail does not quite wag the dog. But all these things are used far and wide, even in places where coal is not needed for heat.

There is another curious fact. It really is not a part of the doings of coal, but is connected. Bran oil is now made from oat husks, corn cobs, wood pulp and other waste from all sorts of grains—things that were just thrown away, cluttering waste! From the bran oil can be made many of the same products as from coal-tar. Perhaps not so surprising when you come to think of it! Both are from vegetable life, even though coal is so very much older. Bran oil is not yet developed to any great degree, but watch it!

The Hydrocarbons are a very closely related Family, are they not?

* * *

What is this coal? How does it work such common everyday miracles? So used to it are we that we forget the wonder of it.

If you drive through French Canada at every farm you see great piles of wood, cord wood, four feet wide, four feet high, and yards and yards long, like a thick fence, or wall. It was cut last winter, dried out all summer, and will be used for heating and cooking all next winter.

Coal was once wood.

How do we know? Because wood and leaves are found with it. Some are preserved right in the coal itself. The little cells of the wood can be seen under the microscope. Beautifully preserved leaves, bark, and wood are found in the beds below it, the mud beds in which the plants grew, and in the beds above which finally covered the swamp. And in the coal beds themselves, in places, are 'coal balls', round hard lumps

which when opened have preserved within them the most fragile leaves. What made the 'coal balls'? Some of the mineral matter in the water fell on the leaves before they were destroyed. Once started the mineral matter slowly surrounded the leaves and preserved them from whatever happened afterwards. 'Coal balls' do not occur everywhere but there are enough to tell their story.

This, then, is one way we can prove coal was wood.

Then, coal must have lived once. It did. But how did it become coal?

THE STORY OF ONE LITTLE LAKE

It was born long ago, in New York State, or in Ontario, or, in truth, anywhere across the northern part of the continent. I do not know exactly where. There was no United States or Canada. It was just a continent without a name, and without a human being.

The glaciers had melted far to the north, and the nameless continent that is now North America was slowly rising, throwing from its back the great wastes of melted ice water. First a few islands appeared in the watery expanse. There is one worth watching! Higher and higher rises the island. More water comes in from the north and along the channels of the Great Lakes. It pushes back the sea-water and itself flows on to the sea, as the continent rises!

In time our island becomes a hill which stands high and dry. Now we can look at it. It is just rubble, glacial till, dropped at the end of a melting glacier. And at its feet stands a little lake, surrounded on all sides by gently sloping land. And right across the front of the

lake across its path stands the hill. The water cannot get out.

Let us look at it later, ten years later, twenty years later, fifty years later or even one hundred years later. Around its edges small plants have begun to grow. In the water, warmer now, appear floating algae, a very simple form of plant life. Over the country-side and on our hill, bushes and then trees are beginning to appear. Slowly the Earth is being re-clothed. The plants die and some of them are carried into the lake by stormy autumn winds. And the pollen from the trees, and some branches are carried in. By this time water plants are growing right in the water around the edges. Year after year they live and die, their dead leaves and flowers fall to the bottom, and mixed with them are the leaves and pollen blown from the trees on the hill.

Slowly our lake is being filled up with muck from the decaying vegetation. Each spring more water comes down and plant life begins afresh. But the water cannot flow away because the hill stands guard, right across the path. Each autumn more leaves, more branches pile in. Finally, scrubby bushes grow in a tangled swamp, first at the edge, then right over the whole surface of our little lake.

In time peat-moss, a greyish-green or whitish moss, grows out beyond the former shores over the living and dying mass. The trees, no longer on the hill only, have come down to the swamp edge. They creep across the erstwhile shore and year by year over the place where our lake has been. And they, too, die and fall. Slowly, very slowly the lake disappears.

Someone carelessly driving past just says, "A peat bog."

There are many peat bogs, large and small, particularly over the country where glacial debris stopped the drainage.

Have you ever seen a farmer's claim on a peat bog? It is a good place to study peat. I know a bog that the neighbouring farmers have divided. Each has his own share. It is in a very, very deserted lonesome-looking country-side. I followed a waggon trail over a sand hill, through some trees and down a slope. A wide, low country dark with scrub and small trees lay before me in a hollow. Near at hand the larger bushes were cut back, and a space irregularly cleared. A fringe of untouched dark forbidding-looking bushes marked the edge of the clearing. Farther down were reeds and soggy soil. Still farther was stagnant water. I stepped off the trail and the ground was 'springy', not wet, but like a mattress. On either side of the trail and some feet below it was a brown-black uneven floor. It could not be called a ditch because it was wide, and it was dry, and had a more or less even bottom. Back of the sunken floor was a wall of peat bricks.

Each farmer cut his peat whenever he had time in the summer, cut it into large bricks, and piled the bricks along the edge of his 'cut' to sun-dry. The cuts might be any depth, depending on the depth of the original lake that was filled up. For this might have been our little lake. Then in the autumn the farmer carried home his peat.

Peat is very light and requires a great deal of storage space. Where there are great quantities of it, it is

pressed into bricks or briquettes and used in that way. You know now wherever and whenever you see it, peat is made from decaying vegetation.

Old peat at the bottom, in general, will be dark, much darker than the more recently made top layers. And it will not always be pure. The spring freshets may carry mud and sand into it. A forest fire may burn the surrounding trees and fill it with ash. And then again there is the mineral matter that the plants take up.

But where do the peat-bog plants get their minerals when they grow, not in the soil, but on top of their own plant-made muck? The dead plants contain minerals. The mineral matter may pass on and on from one generation of plants to another. That is good for the peat. The whole mass will not have so much unburnable mineral matter in it.

Trees With Knees

There are other and larger swamps and bogs—the Dismal Swamp of North Carolina and Virginia and others which lie along the low coastal plain between the Appalachians and the sea.

There are forest swamps in the hot East Indies and mangrove swamps form along the seashore in many tropical countries. When the trees come down to the shore near these great swamps, some of them turn their roots into stilts, and each stilt has a knee. All around the trees the roots spread out and down, knees at the turn of each root. There stands the tree above the water.

AND COAL!

What has this to do with coal? Everything! This was the way coal was made and is being made. We now get it from a coal mine.

A coal mine is very different from a gold mine. Yet there are some things that are the same. There is a shaft, the elevators, the miners, the galleries, the digging out from the walls, the shaky, dumpy little cars.

There are big mines and there are little mines. Down the Mississippi valley you may drive along the road and see a hole in the hillside, where a man or two has been digging out. In some places the mines have been worked out right under the sea. And there is every size between.

* * *

When was this coal mine, now far below the surface, a lake or swamp on the surface?

Look back at the end of Page Two of the Story Written in Stone. Most of the continents then were free from the sea, and on the continents were plants. In many places were swamps not unlike the Dismal Swamp of the South. From then until now coal has been formed.

FROM WOOD TO COAL

But why is the wood preserved? There are thousands and thousands of square miles of wooded hills and valleys in the world, and they do not make coal.

When wood dies in the air it disintegrates—falls apart. Water and the oxygen in the air just slowly burn it up. You do not see it burn. It takes so long. The gas CO_2 (more chemistry!) passes into the air. CO_2 is more about atoms and molecules. Two atoms of oxygen and one of carbon just fly off together in the air. And besides, water is formed—that is H_2O —two atoms of hydrogen and one of oxygen. They, too, take French leave and calmly soak into the ground. And all the min-

eral matter just lies carelessly where it falls. So there is nothing left of the coal, just the ash. The wood all disintegrates, falls apart. But not all wood disintegrates.

First, we have wood. It grows now and we burn some of it. Then, we have peat. It grew long ago—at least the part of it that we burn. Then, we have brown coal or lignite. It grew longer ago, on Page Four and Page Three.

Brown Coal or Lignite

Brown coals are one stage. As it lies at the bottom of the deposit some of the water is pressed out, and, from the pressure of what lies on top of it there is a little heat.

Since the brown coal has not advanced so far in the process of becoming coal it follows that it has been formed more recently. That is true—in general. There are a few coal deposits in the older rocks the coal of which is still a bit brown but that means that they have been but little disturbed.

But think again. Brown coals are younger. That is, they were made after the land plants had evolved into many kinds. They had seeds and pollen. They are made of different plants.

Bituminous Coal

What is that? Look back at page 203. Artificial gas is made from coal. Oil, too, can be distilled from coal. Bituminous coal has much oil. Just get in the way of the smoke of an engine. That dirty black smoke and the smut on your face comes from bituminous coal. 'Soft' coal, we call it sometimes. Your mother knows it, if she

hangs out some clean clothes when the wind is blowing from a factory or from a large apartment house.

Look at a piece of wood with a magnifying lens. See the tiny cells. You can see them in your hardwood floor or in a piece of furniture. Those are the little tubes up which the life-giving sap flowed, right to the very tip of the trees and the leaves. When the trees die the cells are empty, the sap oozes out or dries out.

Let us stand at the edge of one of those great swamps of long ago. A great tree falls and sinks into the moist muck. In that moist muck is the goo of past decay which penetrates up and through those cells. The log is slowly saturated. It lies there and is covered and many things go on above it, continents rise and fall, mountains are born and worn down. Still it lies buried.

Then along comes man and begins to dig out the wood which is now coal. That log into which the decayed matter has soaked is full of oil. It has made bituminous coal.

That is how it happened.

Cannel Coal

It is cold and blustery outside. The trees are lashing at one another with their naked branches. Snow or sleet is falling in spurts.

But we are cosy here. Put another piece of coal on the grate fire.

Yes, the chunks are large, but crack it this way with the poker, along this edge. See, it breaks with smooth and squared edges. The furnace coal does not break in that way at all.

What a fine bright flame, roaring up the chimney!

Hear the tar in the coal sizzling! Put on the fire

screen. Sparks may spit out on the carpet. Well, that soon drives away the blues of a wild autumn night!

What is this coal?

Cannel coal.

Away in the northern part of North America, in northern Canada, are hundreds of lakes hidden here, there, and everywhere between the hills of that Canadian Shield. The hills, many of them, are covered with conifers, trees that bear cones. You know them—pine, spruce, hemlock, Canada balsam. And among them are many other flowering trees and mosses. And flowering trees have pollen grains. Other plants have spores. At certain times of the year the spores and the pollen grains scatter with the wind, far and wide. They fall, some of them and float as a thick scum on those hidden lakes, and on some not so hidden.

The spores and pollen grains for protection are covered with a fatty substance. The fat makes oil.

And cannel coal was deposited in the older swamps in stagnant water which has been covered by spores, and in the later swamps by pollen grains, season after season.

Anthracite Coal

Have you filled the furnace for the night? This coal is different, small lumps and very hard.

What is the difference?

It does not break and crackle. It has not much oil. It does not flame. It is harder to start, but it burns with a steady glow and it lasts a long time. It is 'hard coal'—anthracite coal.

What makes it different?

You can see, as I said, there is not much oil in it.

Nor are there the sudden quick explosions of gas that the cannel coal makes in the grate fire.

Why? They were all made from vegetation.

The oil and gas have escaped which means that each shovelful has more pure carbon, because it has less of oil and gas.

But how did the oil and gas escape?

Perhaps the layers that lay above these coal beds were porous, and the oil and gas seeped out. That is the case in some places. But that will not account for all the anthracite coal in the world.

The anthracite coal of North America is found in Pennsylvania and in Alberta.

Do you notice something, common to both places? Look at your map.

Pennsylvania is crossed by part of the Appalachian Mountains, and that is where the anthracite coal is found. The Rocky Mountains cross the west side of Alberta, and that is where the anthracite coal is found.

Does that mean anything?

Oh, yes. When those mountains were built up there was heat and pressure. The rocks about the coal beds were cracked, pushed and pulled, and so were some of the coal beds. And through those cracks and fissures escaped the oil and gas.

Peat may become brown coal, and some of it may become bituminous coal, but some people who study it in thin sections with the microscope do not think that brown coal or bituminous coal will become anthracite, even through the escape of oil and gas. Another possibility is that anthracite is made chiefly of wood, tree trunks.

WHERE DO WE FIND COAL?

Almost everybody knows that coal comes from Pennsylvania and from practically all the States around Pennsylvania. We have mentioned the coal of Alberta. Down the Mississippi valley there is coal in abundance in Ohio, Illinois and Indiana. Most of the Mississippian coal is soft, more bituminous than the Pennsylvanian or Albertan coal. There is much of that soft coal in Nova Scotia. There is a cliff there, of the muddy grey rocks, along the Joggins coast, and standing upright in it, are hundreds of fossil tree trunks.

Europe

"Oh," says a man walking down the street, "why bring coals to Newcastle?"

Newcastle in England is one of the great coal centres of the world. Why bring coals to Newcastle? Why, indeed! That, means the man, is absolutely unnecessary. Newcastle has enough coal.

South Wales is another great coal centre. Welsh coal is anthracite. It burns leaving little ash. I know, because I have used both Pennsylvanian and Welsh coal in my furnace.

Germany has the largest supply of coal in Europe, so far as known. The word 'Westphalia' just makes you think of coal. But there are other provinces of Germany with coal.

Russia has coal, and when all is known there may be more in Russia than in Germany.

Most of the other countries have small supplies, and in some of the smaller countries of Europe what they have has not all been developed.

Asia

In Asia by far the greatest known resources are in China, where there is abundant anthracite.

Siberia, a part of Russia you know, may have some. As yet we do not know much about it.

There is some coal in India, but just how much we do not know.

Most of the other countries of Asia have coal, but it is mined in a very primitive way.

Africa

There is coal in Africa, too. Most of it is in the southern parts of the continent, and much of it is lignite or bituminous coal.

But in that African coal is a plant, 'Glossopteris' it is called—such a name for a plant!

Over in South America 'Glossopteris' grew, too. The specimens of the plant are poor, but that is what they are, according to some of the people who study plants.

Well, how did the plant get across the Atlantic Ocean to South America? The spores could not float all that distance. How then did *Glossopteris* get there?

The Atlantic Ocean is shallow, for an ocean, between Africa and South America. Do you remember the mountain range drowned in the Atlantic (see page 76)? Some men think that not only a mountain range but a whole continent lies drowned under the South Atlantic Ocean, that once this drowned continent stood above the water, that the *Glossopteris* spores blew west and then again west, hopping to the now drowned continent, thence westward to South America. Then the continent sank, but *Glossopteris* was safely across.

We will have to know more before we are sure. It

is rather a heavy responsibility for a plant with such a name to suggest that there must have been a continent.

South America

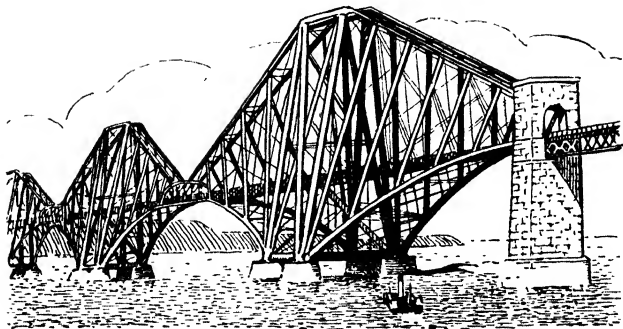
There is some coal in Colombia, more in Peru, but not so much in a few of the other countries, and none in some of them.

Australasia

There is a considerable quantity of coal in Australia. and some in Tasmania and New Zealand, but not so much as in Canada and in the United States.

CHAPTER VI

IRON



Ah me! What perils do environ
The man that meddles with cold iron.

SAMUEL BUTLER

"HEY THERE, FRED, turn those cows," called Fred's father. "And hammer a board over that hole in the fence. We won't have a carrot left."

Fred stopped pitching his ball against the barn wall, to chase the cows. It was milking time. The idling cows nosing around had found the way out of bounds into the garden.

Reluctantly Fred went into the workshop. His pocket full of nails, hammer in hand, he attacked the hole in the fence. As he hammered it suddenly popped into his mind, "What is a nail? And, for that matter, what is a hammer?"

Iron, both of them. Fred looked around. "How many things can I see made of iron?—the pump, the plough, nails, hammer, nearly all tools, the wire fences around the fields, screws, the lightning rod up the barn, the hoe, the tractor." On and on he went.

Make a list of all the other things you can think of that are made of iron.

Fred, of course, lived in the country, and perhaps you live in the city. But that does not make any difference. And if you travel from the country to the city don't forget the train in which you travel, nor the tracks over which the train runs, nor the bus, the bridge you came over—on and on.

We have to breathe air. We have to drink water. and we have to eat food just to live. But, I wonder, besides these life necessities, if there is another thing in the world we use more than iron, or the things made of iron. I wonder!

WHAT IS IRON ?

Iron, too, like copper and tin is one of the treasures of the Earth. And not only of our Earth but of other stars as well. Pure iron is not very common. When it is pure it forms a very bright crystal. It is brilliant silver-white in colour and can take a very high polish. Also it is magnetic, that is, it acts like a magnet. It, with other things, easily forms a salt. There are several kinds of iron salts. And they very readily change their nature. Again the question of atoms and molecules about which you will learn more in chemistry! But you know perfectly well without chemistry that iron rusts—that is one of the changes which means the atoms

re-adjust themselves. For some of those atoms unite with the oxygen in the air.

Iron is generally found in rock—and such rock is called iron ore.

But did I hear you ask, “Does it occur in igneous rocks or in sedimentary?” The answer is—it occurs in both.

In Igneous Rock

Have you read of the Giants’ Causeway in Ireland? That is basalt, a kind of rock formed from volcanic action. There is iron in it.

We get iron from other stars! Really we do. Meteorites! Not all meteorites are made of iron. Some are stone. But often they are made of one of the purest forms of iron. Smooth, rounded masses of all shapes and sizes, they land here literally out of the heavens. Have you seen one? When you do you will have no doubt whatever about its having been melted. A meteorite is often irregularly pitted on the outside, hard and heavy, but so smooth, not a sharp edge anywhere. It came through the atmosphere of the Earth at such a rate that the outside was melted, hardening again as it cooled. It arrived here warm, but as hard as—well, as hard as iron, for that is what a great many of them are—iron with some nickel. You can see meteorites in some museums. When cut through they display the brilliant silver-white colour and are often polished in the showcases, revealing the long criss-cross crystals. Very pure they look and very beautiful.

Meteorites large and small are found in many places in the world. They, of course, have nothing whatever to do with the country rock where they are found. They

may fall anywhere. There is supposed to be a very large one buried deep in Arizona. It has made a great hole in the Earth, at least that is what is believed. The great hole is there and hundreds of little meteorites are all over the place. But, if the big hole was made by an immense meteorite the latter has never been found. It has buried itself too deeply in the earth. Meteorites are not a source of iron, commercially. They are generally too small and too scattered. They are more of a curiosity. But they show us a number of things: the iron crystals, the fact that iron exists in almost a pure state and that other stars have iron.

It is now thought that the centre of the Earth is iron, or iron and nickel. Do you remember on Page One of the 'Story in Stone', where all the men who had thoughts about the birth of the Earth, differed in many ways but they all agreed on one thing—that whenever the whole Earth or parts of it were molten, the heavy parts sank down towards the centre?

And then there are those earthquake people. They have found out things about the Earth, too. They find that the vibrations from an earthquake travel fast and faster through about the first 600 miles or so of the Earth. For another 1,200 miles or thereabouts, they go faster more slowly, that is, the increase of speed is not so great. Then through about 4,000 miles at the core of the Earth, the increase is very great again, much greater than through the first 600 miles.

Up here on the surface of the Earth, in a smelter furnace where iron is separated from the ore, a great mass of the smelted ore is poured into containers and it sorts itself: the heavy metal sinks to the bottom; the

other mixture—sulphides and oxides they call them—lie on top of the metal (they are lighter in weight) and above that is the frothy slag!

Now all these things point one way. It cannot be proved yet. Some other facts may come to light. But as it stands men have changed their thoughts about the centre of the Earth, each man mounting on a step built by one before, just as they did when thinking of the birth of the Earth.

Long ago it was thought the Earth was full of molten matter. It was warmer down a deep mine, geysers vomit up hot water, and volcanoes pour out lava. Who would not think the centre was molten!

But in the meantime all these other things have been discovered. Now it is thought that the core of the Earth, about that central 4,000 miles, is mainly iron and nickel, that the next 1,200 miles or so, is something of the nature of the sulphides and oxides, and the last 600 miles on the outside is rock, heavier in the lower part, and just slag-like on the outer crust.

So, iron is found in igneous rocks.

In Sedimentary Rock

And then, is iron found in sedimentary rock? Have you ever taken water out of a pump that has not been used for some time? It is not good. It tastes of iron from the long pipe in which the water has been standing. Iron dissolves fairly readily in water. It is not the iron that will hurt you in the water standing in the pump pipe. It is other things. There is often iron in drinking water.

And we have iron in our blood. If we do not have enough of it we become pale and weak, and to get more

iron we eat liver or something disagreeable that the doctor gives us.

So you see, iron is readily dissolved. You can see why when you remember that it is usually in the form of a salt.

But all these sources of iron: water as you take it in a pail, plants or even the soil where the plants get it—all these sources are not enough. The quantities are small.

But if iron can dissolve in water, given time water can re-deposit it. And it does. It is doing it now and it has done it since the beginning of time, or of water. So you see iron can be in sedimentary rock.

When I was out making a map of the rocks in a certain district an old farmer with a gleam in his eye said to me, "Did you see that hill over there behind the bush? A fortune-teller told me, that hill is my fortune. There is oil in it."

Now I knew that the rocks underlying his farm were lying directly upon the ancient rocks of the Canadian Shield, that there had been little life when they were laid down, that nowhere in the world has oil been found in rocks so old.

That gleam in his eye meant "Don't you dare tell me there isn't oil there!" So I went carefully, very carefully.

"Is there a swamp on one side of your hill?" I asked. innocently.

"Why, yes!" he answered, surprised that I knew without having been there. But you see I knew the whole wide country was full of those glacial boulder hills with large and small rocks piled higgledy-piggledy

together, and most of those hills were stopping the drainage and forming bogs.

"Is the oil on the water?" I asked.

"Yes," he said.

You know how oil floats on water making an iridescent pattern of many colours when seen in the right light.

"Next time you see it," I added, "poke your finger into the surface. If it is oil it will flow together when you take your finger out. But if it is another thing, iron oxide, it will leave cracks radiating from your finger point."

For there is iron in bogs, and swamps. If enough is present it falls to the bottom mixed with carbon and other minerals, forming a soft iron called 'limonite'. The word 'limonite' comes from a Greek word 'leimon', meaning a meadow or marsh.

And in some of these marshes there are certain organisms which act upon the impure limonite and form a soft bog-iron. The yellow ochre you see in your Art class is limonite and clay.

In some places in bogs it gathers together in concretions forming hard heavy stones of iron in a form called 'marcasite'. Break them open and within are crystals radiating out from the centre, a very beautiful form.

So, iron is being deposited now.

And it has been deposited through the millions of years in the past. When it is all added up, you see that iron might occur in rock of any age.

Look back to the story of Page One. The rocks laid in the inland sea have left vast stores of iron in Minnesota, Wisconsin and Michigan. In Europe much of the

iron is in rocks that belong to Page Three of the Great Composition of the Story of the Earth.

NATIVE IRON

Iron is found in many forms, sometimes in shapeless masses, sometimes in crystal form.

Limonite

I have told of limonite and bog-iron and marcasite. Now if limonite is heated somewhat and the water driven out it may become hematite.

Hematite

There on the table are three lots of hematite. They do not look very much alike, do they?

This first one is massive, almost black, and darkly shiny. Take it up if you can lift it. Very heavy, isn't it? Scratch it with your knife edge. The scratch is red—blood-red.

Now try this piece. It is a conglomeration of roundish bumps, reddish-bronze in colour. Break off a lump. It is crystallized. Scratch it. Again the scratch is red. Blood-red!

That third piece, over there, is blood-red anyway. You do not need to scratch it. If this last piece of red hematite came from Lake Superior, and perhaps it did, the Indians knew about it. You see, it is softer than the others. The Indians used it for their war paint.

All this hematite probably was limonite once. Somehow it was heated, at some time. That is not surprising around Lake Superior. For on Page One, remember, there were lofty mountains here and that means volcanoes and molten rock welling up from below. In the

heating, the limonite lost the water that might have helped it to crystallize. So here it is a dull red mass.

Dark or red, in this form or in that, it all makes a red scratch, blood-red. And that is where it got its name, from a Greek word 'haima' meaning blood.

Hematite is one of the greatest sources of iron. In the United States, something like 90% of the iron mined is hematite.

Magnetite

I know a lake up north on the Canadian Shield which has a great patch of black or almost black sand. Most of the sand of the region is a reddish, sand colour. Round the Great Lakes the sand is grey. But this is almost black. When I scooped some up in my hand it was heavy, most surprisingly heavy.

These black sands or at least the black in them came from rock containing magnetite, another iron ore, black this time.

Have you a magnet? It is almost the same word, isn't it? Put some needles or iron filings on your table and hold the magnet in your hand beneath the table, touching the wood. Watch the needles follow the magnet.

Well, magnetite is magnetic. It has that same force.

Once, long ago, a shepherd was wandering with his sheep on Mount Ida, on the island of Crete, south of Greece. (Look at your map).

In his hand the shepherd had an iron-pointed staff, so the story goes. Somewhere on the mountain-side were those same black sands that I saw in that northern lake. When the shepherd, walking along, put his staff in the sand he noticed that all the very black grains stuck to

the iron point. He could rub them off. But he could pick them up again, by the end of his staff.

The shepherd's name was Magnes!

So came the words 'magnet', 'magnetism' and 'magnetite'. For it was magnetite sand that stuck to the iron point. That is one legend.

Have you a compass? It always points north. But not to the North Pole. It points to the Magnetic Pole, some distance southwest of the North Pole.

Pyrite

Come with me across the field. There is a man there who thinks he has gold. Has he? Let us look.

The rock beneath this farm is limestone. You see we are walking over it here. It is almost flat, and cannot change much in the length of this field. You remember gold comes from rock that has been melted. If there had been melted rock so near this limestone there would have been some disturbance. The limestone would not be so calmly flat.

Let us see. A broad white vein cuts through the limestone, without twisting it, or cooking its edges. Is it quartz? Gold often occurs in quartz. But if melted quartz cut through limestone like that, the rock on its edges would have been cooked. And this is just as it was.

There is another test. Scratch it with your knife. (A knife is so handy!) The white rock shows a white scratch. It is soft. Quartz is harder, much harder. You cannot scratch it so. This is crystalline calcium carbonate, that is, just crystalline limestone.

"But," insists the man, "there is gold in it. See

there!" and he points to some bright shining gold-coloured cubes. They look exciting, and he is excited.

But hand me that bottle of acid, hydrochloric acid. We will try it out.

See, the acid just eats it up.

That is iron pyrite—Fool's gold! and it has fooled many a man.

How did it get there?

Water percolated through that crack in the limestone carrying in both dissolved limestone and dissolved iron and sulphur (for iron pyrite is iron and sulphur). The iron and the sulphur united in that strange way minerals have. And as the water slowly evaporated it deposited the limestone in a crystalline form, bit by bit, and deposited with it the cubic crystal of pyrite.

Pyrite also occurs in quantities in igneous rocks and in metamorphic rock (you remember that word; look at page 13). When in such rocks it usually means those rocks have been very highly heated.

Pyrite or pyrites, as it is called, can be seen in many rocks. It rusts easily, when exposed. Common as it is, it is not good for mining iron because it is difficult to separate the sulphur from the iron.

MAN-MADE IRON

If iron occurs in igneous rocks and in sedimentary rocks and if it can occur in sedimentary rocks down through all the ages, think what a lot of iron there is on the Earth, not to mention what there may be at the Earth's core. That is well, since we use it so much.

Look at the list you made of the ways in which we use it.

All those made irons are not the same, are they? There is wrought iron, cast iron and far and away above all there is steel.

‡

Wrought Iron

Let us go back to Persia, or somewhere there on the Eastern Mediterranean. The Cave-man we saw on Page Four is dead. In fact, probably many of his great-grandchildren are dead. This is another man, still a savage, but he can make a fire.

He has had a meal. I don't know which one because I am sure he did not have three a day, every day, as we do. But his fire is out now. All about him is desolation. He has come back to one of his hunting-grounds. The forest where he caught his game has been burnt to a cinder. Perhaps it was from the fire of another savage, perhaps it was struck by lightning. When he made his own fire he laid down a stone tool. Now he wants to find it. He pokes around in the ashes with a piece of hard stick. The very ground all around is still warm from the forest fire. One stone he pushes out of his way still has a red glow. He pokes it. The end of his stick smoulders. But here is a very strange thing! The end of the stick has left a hole in the stone. The red glow is dying and his stick leaves less and less impression as he curiously pokes the stone. Farther on he finds another and another stone still warm. The glow dies before long on them all. When cool he wonderingly turns some of the stones. He learns that this particular kind of stone is heavy, very heavy. He pounds it and finds he can change its shape.

Some men think it was in some such way that men

learned that these stones, which had iron in them, could be hammered into different shapes.

Or, it has been suggested, some worker in copper long ago tried what he could do with iron, and found it, too, could be heated and softened and then hammered into shape.

Whether the use of iron was discovered in this way or in that, certainly men learned that an arrowhead of iron was sharper and altogether better than one of stone. So they made iron arrowheads.

The first iron stones men found and worked were probably meteorites. When the white man explored North America he found the Eskimos of Greenland were hammering out crude weapons from pieces of meteorites and so were some of the Indians on the west coast, hammering them cold, with other pieces of stone. They worked away a long, long time to get a piece free from the main meteorite. But time was nothing to them. They had not learned the use of heat in softening them.

Many of the men who study about early man think the Iron Age, that is, when men began to use iron tools instead of stone, came after the Bronze Age, even though bronze was more difficult to make. Others are not so sure. It really is possible that in some places where there was iron and not copper men learned to use iron. In Africa, for instance, there was no Bronze Age. The Iron Age followed the Stone Age.

Or, on the other hand, where there was copper and not iron they learned to use copper.

The very first known record we have in the world is in the Bible, Genesis IV, verse 22: "Tubalcain, the forger of every cutting instrument of brass and iron." Just

how many thousands of years B.C. that was we do not know. But the man who first wrote that thought it was pretty near the beginning of human life.

You remember the old tin pail is iron covered with a thin coating of tin. Iron, then, can be pulled out, and made into any shape you want. It is rolled into sheets to make the tin pail.

Let us visit a blacksmith's shop. We must go to the country. There are a few left there. Farmers' horses still have to be shod.

Under a spreading chestnut tree
The village smithy stands;
The smith, a mighty man is he,
With large and sinewy hands;
And the muscles of his brawny arms
Are strong as iron bands.

The Village Blacksmith—H. W. LONGFELLOW

That was written in New England. Every village had its smithy, where now we have service stations.

Let us go to the door and watch him.

He turns the bellows on to his forge. It glows and glows.

See, in the forge he has a long iron bar. It is black at this end though hot to touch, but right in the fire it is first red-hot and then white-hot. When its colour shows it is heated enough to work the smith lifts it from the forge to the anvil where with ringing blows, he hammers it into the shape he wants. Sometimes he dips it quickly into water.

The village smithy's main work now is making horse-shoes but he used to make many other things, or mend ploughs and pipes for pumps, and in large foundries

they made iron fences and gates, and many other things.

Such iron is malleable, that is, it can be shaped by hammering or by a mallet. That is the origin of the word. In other words, it can be 'worked'. It is called 'wrought iron'. 'Wrought' is an old word, the old form of 'worked'.

In many places in Europe you can see beautifully wrought-iron gates and doors, and railings. Indeed, many things!

Cast Iron

One day, probably long after it was found that iron could be hammered out, someone working away with iron, heating it to hammer it, found that it melted down so that it could be poured, or that sometimes it could be poured. Some of it may have fallen on a hollow stone or between stones or into a hollow in the clay, into something that could hold it without catching fire. When cooled the iron took the shape of the mould into which it had fallen. The first cast iron!

Why was some of it easier to pour? The man who first discovered that it could be poured into a shape did not know why, but we do know. It had a great deal of carbon in it. Iron readily takes up carbon, and possibly some of the burning wood of the fire became mixed with the iron. At any rate, iron with carbon can be shaped by being poured into a mould but it cannot be hammered into shape, hot or cold.

And so we use cast iron now for many things. But the method of casting or pouring into moulds is used even more for steel.

Steel

The form of iron which we use most is steel. When the descendant of our savage friend in Persia or the East accidentally let his hot soft iron stone roll into a near-by stream he heard it sizzle but he thought nothing of it. Every time he dropped water on the hot stones of his fire there was a sizzling and a spitting.

But once, perhaps, he pulled a piece out to hammer it again. It was different. It was harder and broke at his heavy pounding instead of taking the shape he wanted.

Why? Because it had cooled suddenly. That was the first man to make steel. Or, probably that was the way it was first learned that iron cooled quickly was stronger and more brittle.

That process of heating and cooling quickly is called 'tempering'. 'Finely tempered steel'! It will take a finer edge. It will not wear out so quickly. It will not only make spearheads, but swords and knives on chariot wheels. Later the swords of Damascus were famous for their finely tempered steel.

Now all these things were learned somewhere east of the Mediterranean. At least, that is what is thought.

Iron has been found in one of the pyramids of Egypt, built at least as long ago as 3,000 B.C. Probably iron was strange to the Egyptians. They used only a little of it, and then only for sacred things, such as burial. At any rate, when the Israelites left Egypt, wandered in the wilderness and finally invaded Palestine they had no weapons to match the Philistines, and the Canaanites, armed with swords, and chariots with steel knives. Look at your Bible again. Joshua XVII, verses 16 and 18:

"And the children of Joseph said, 'the hill is not enough for us; and all the Canaanites that dwell in the land of the valley have chariots of iron'."

And again, I Samuel XIII, verses 19 to 22: "Now there was no smith found throughout all the land of Israel . . . but all the Israelites went down to the Philistines to sharpen every man his share (plough-share) and his coulter and his axe and his mattock . . . So it came to pass in the day of battle, that there was neither sword nor spear found in the hand of any of the people that were with Saul and Jonathan. But with Saul and Jonathan his son was there found."

This was all during the fourteenth or fifteenth century B.C. or perhaps even earlier.

The use of iron and steel travelled slowly westward into Europe. Homer mentions it among the Greeks about 1,200 B.C. By the time it appeared in Europe weapons were decorated often with fancy curves.

But steel as we now have it is prepared in many ways, in many types of furnaces, and the iron united with other minerals to give it different qualities. But still the carbon content is the important part. It is not just chance now. Carbon can be added.

For wrought iron very little carbon.

For cast iron, much carbon.

For steel, varying quantities. It must be malleable at different temperatures for different types of steel.

Then, of course, there are other variations depending on the length of time in cooling and on the way in which it is hammered, pressed or poured, or any other method. For steel, too, is now poured.

Iron has the most varied characteristics: it is hardened by sudden cooling, softened by slow cooling. We make steel hammers so hard they can cut other softer iron and steel. It may be brittle or drawn out into long thin wire. It may be magnetic or non-magnetic. It has many other contrasts.

WHERE IS THE IRON OF THE WORLD?

North America

In North America the largest supply is around Lake Superior, in Minnesota, Wisconsin and Michigan. It is hematite, and most of it comes from the Mesabi Range.

And remember the coal in the Mississippi valley, principally in Illinois and Ohio! That means cheap smelting.

For more than fifty years this region has been the chief source of iron. A great deal of iron has been taken out during that fifty years and—well, how long will it last? Not for ever!

The next greatest supply is in the State of Alabama. It is a lower-grade ore, but will probably be used more and more as the Lake Superior supply gives out. The Alabama iron, too, is hematite.

Then, several places in the western States have small supplies of magnetite. There is a little in the north-eastern States.

Canada, up to date, has not had enough for its own use. But all the story is not told. North of Lake Superior is a lake, Steeprock Lake, not very large compared to Lake Superior, but not so small for a twisted turning lake. A few years ago great boulders of iron were seen on the shores of one part. Search was made for

the rock from which the boulders came. Nowhere did it show. It must be under the lake! It is!

Now a dam has been built. The branch of the lake beneath which lies the iron is being pumped out. Then the iron will be mined. This is a very high-grade hematite.

Up in Labrador explorers recently have found immense quantities of hematite ore, high-grade ore too, which bids fair to be one of the great supplies of the world. But alas! that too, is far from coal and cheap smelting. But Canada with her iron and electrical power may yet develop a great iron industry.

There are many other small deposits of magnetite iron, particularly in the Ontario part of the Canadian Shield. They were mined years ago before the discovery of the great Lake Superior supply.

There is a great deal of iron ore in Newfoundland. It contains much phosphorus and requires a particular type of smelting. Next to the United States, Newfoundland now has the greatest output in North America.

Most of this iron of North America comes from the rocks of Page One of the Earth's own story.

South America

There is some iron being mined in Chile, and Brazil has large supplies. It is known there is some in Venezuela and elsewhere, but there is still much exploratory work to be done.

Europe

Britain has an abundant supply of iron ore, mostly hematite, but not all of it is of good grade. And Britain has imported quite a bit of the ore for her steel from the continent. But, you remember about 'bringing

coals to Newcastle'. Right near her iron deposits there is a great supply of coal for cheap smelting. So that Britain has built up a huge steel industry.

In the Ruhr valley on the continent lie great iron and coal supplies, to build up the iron and steel industry of Europe. And these supplies pay no attention to political boundaries. Germany is in it. France is in it. Belgium is in it and even little Luxembourg has her finger in that pie. European wars have pivoted about the region. This great supply of ore is not of the highest grade. It, too, contains much phosphorus.

Sweden has some of the highest-grade ore in Europe, of the magnetite type. But Sweden lacks coal for cheap smelting. Sweden ships her ore to other countries, chiefly to Germany.

Spain has had some iron ore, but most of it has already been mined. Austria also has small supplies.

Russia is the unknown quantity. Most of her known iron is of a rather low grade.

Africa

Across North Africa in Algeria and Tunisia is quite a lot of hematite iron. There may be still more in Morocco. Look at your map. See the Atlas mountains. It looks hopeful! But alas! There is no coal for smelting. Most of it is shipped to England where it is smelted and made into steel.

In South Africa near Pretoria is iron, and near it is some coal. The quantity is not large enough nor pure enough for more than local supply. Iron ores are found at various places in other parts of Africa, but not much is yet known of them, and they are not yet mined.

Asia

Japan has one big supply, but it is poor ore. Japan has the coal for smelting but most of her ore is imported from other countries.

China has reserves but, except for one field of magnetite on the Yangtze river, it is a poor grade. Very little of it has been worked.

India has the greatest supply in Asia, some of it high-grade hematite. But Indian coal is not very good. The Indian ore has not been greatly developed.

Australasia

Australia has enough for her own use but little to export to other countries.

Of the islands the Dutch East Indies has large supplies and there is coal in the region, but the ore is moist and has other material in it so that it requires special processing.

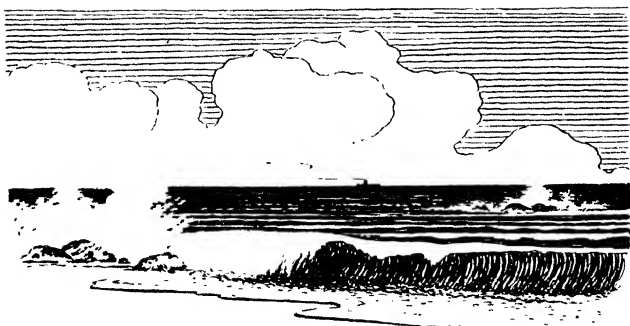
Several other groups of islands have small supplies, none of them more than can be used locally, if they were developed, and few of them are.

* * *

Iron, then, is a treasure to us in the Earth's storehouse. It is well that there is much of it!

CHAPTER VII

WATER



Everywhere the water is a thing of beauty,
gleaming in the dewdrop;
singing in the summer rain;
shining in the ice-gems
till the leaves all seem to turn to living jewels;
spreading a golden veil over the setting sun;
or a white gauze around the midnight moon.

JOHN B. GOUGH

WATER A TREASURE in our Earth's storehouse! Is it a treasure?

Just what would your life be without it? Think, think hard. You will agree that water is a treasure. For our very life depends upon water — plant life, animal life, human life. Think of the Earth without life!

But more than that, think of the ways in which we use water, besides drinking it! Think of the heat and power, steam power and electric power! Think of the way we mix things with it! Think of how it has made the wood grow that is your furniture, your house! Think of the hundred ways it enters into our lives!

But I hear you laugh. "Water is not in rock like the other treasures. It is neither mineral nor metal!"

But, isn't it? How is it different? "Why," you say, "it is liquid!" Yes, it is, but so is iron if heated up to $1,535^{\circ}$ C, so is copper if heated up to $1,083^{\circ}$ C, and so is gold if heated up to $1,063^{\circ}$ C, and so is tin if heated up to 232° C.

Suppose we go on a short polar expedition. Our ship is jammed in an ice floe. Our water supply is all gone. You have been on a desert island and found that gold did not help you. But water you must have. Where can we get it near the North Pole? Out there, outside the ship, is ice. But we cannot drink, nor wash clothes in ice. But—heat the ice to 32° F, or 0° C, and you have water! Water will boil at 212° F, or 100° C.

But, you say, each one of all those other minerals has its own crystal shape. Yes, but so has water. A water crystal is long and thin and six-sided. Undisturbed at freezing point it will always take the same shape.

You can see that for yourself any day in the autumn, if you live far enough north or south for water to freeze. When going to school after a rain, you pass a puddle on the sidewalk. It is beginning to freeze, not enough for you to take a running slide, but long needles of ice are floating on the water—crystals! Stoop

down. Look at them. Take them up in your hand if they are not too fragile.

Yes, you see, water too has a crystal form.

A snow-storm is beginning. Catch some flakes. Gently now! We don't want to break them. Here is a piece of black velvet. Now put the flakes under the magnifying glass or microscope. Beautiful shapes, made up of hundreds of tiny crystals, all with six sides, all woven into beautiful patterns—water slowly freezing out of the air!

So water, like other minerals, freezes at a certain temperature and boils at a certain temperature, and it has its own crystal shape.

Water, then, is a true mineral.

THE STRANGE WAYS OF WATER!

Two Gases

Water is a compound made up of two gases, hydrogen and oxygen. Funny, isn't it, that water comes out of that! It is, again, the chemistry of atoms and molecules. When you begin to study chemistry, one of your early experiments will be to separate some water into its two gases, and you will see, for yourself. Until then, I shall just have to ask you to believe me.

Solid Water

You all know about water freezing. But do you know that it is larger when frozen? It expands one-tenth its size. And that gentle force of increasing in size is very powerful. Do not leave any water in a sealed jar if it is going to freeze, and do be careful of the radiator of your car. It will freeze and burst.

And so will your water pipes on a cold night if they are exposed. Remember the top of your milk bottle!

Water Vapour

Last summer was terrifically hot where I was. Everybody was going around drooping like a wilted weed. And whenever two people met, one would say,

“Isn’t it hot?” It was like the refrain of a song.

“It is not the heat, it is the humidity,” would straightway be the reply.

The humidity—the amount of water in the air!

Boil your tea-kettle. You see the water pass off into vapour. It is in tiny particles. Then at a little distance from the spout it is in tinier particles, so tiny you cannot see them. When the air is humid it is filled with a vapour of tiny particles of water, almost a gas. And the hotter the air the more vapour it can hold.

If frozen water increases one-tenth in size, the water vapour increases seventeen hundred times! Did you ever go down into the hold of a steamship and watch the machinery? I have. Or watch a train? How does it work? What makes those big engine wheels go round?

Steam is made from water by burning oil or coal. Now steam must increase in volume. It is like the laws of the Medes and Persians, unalterable. If the volume of steam is confined within a pipe or a boiler it presses against all sides with tremendous force. That force is used, let out, but directed so that it drives a piston. The piston drives the wheels. If the pressure of steam gets too great some of the steam is let out into the air by a safety valve. You have seen a train let off steam.

Vapour May Burn You or Cool You

I hope you have never burned yourself with steam. You may be badly burned with boiling water but steam is worse. Just the physical process of turning boiling water into steam demands more heat than to boil the water.

But, strange to say, water vapour may make you cooler. Put a dab of water on your arm and let it dry off. It cools you. Why? The water passes off into vapour, but to pass from water to vapour requires heat. The heat is taken from your arm.

THE ENDLESS CYCLE

Water Goes Up

Where is the water of the Earth? In oceans, lakes, rivers, swamps, spread over many places on the surface of the Earth. The ocean, you remember, covers four-fifths of the entire surface of the Earth. Besides that, several continents have many lakes, and some of them are very large. There is an enormous surface of water, all lying spread to the sun's rays.

And how the sun does work! It makes the surface layer of water into vapour all around the globe. Continuously that vapour rises. The hotter the sun makes the atmosphere the more water-vapour the atmosphere can hold. The sun 'draws' and 'draws' and 'draws' the water, all the time, day and night, for when it is night where you are, it is day on the other side of our Earth.

Now the ocean water, the greatest surface of all, is full of salt, but the salt does not evaporate. It stays in the ocean. You remember the experiment with salt mixed with water in a glass. The water dries up we

say. It evaporates. It becomes water-vapour in the air, but the salt is left in the glass. So in the oceans, the salt is left behind. The vapour from the ocean is as fresh water as the vapour from a freshwater lake.

Water Comes Down

The atmosphere gets so full of water-vapour that it cannot hold another drop, unless it gets hotter still. But sometimes instead of getting hotter a cool wind comes up. The atmosphere simply cannot take it. The draught is too much for it. The little particles are drawn together and down it drops as rain.

And so it falls everywhere, 'on the just and on the unjust'. A great deal of it goes back to the ocean from which it came, for the ocean has the larger surface to catch it. But mercifully some of it falls on the land.

THE FATEFUL HISTORY OF A DROP OF WATER

I am the daughter of the Earth and Water,

And the nursling of the Sky.

I pass through the pores of the ocean and shores,

I change, but I cannot die.

PERCY BYSSHE SHELLEY

It floated on top of the Atlantic Ocean. It was blown by a storm around some islands into the Gulf of Mexico where it was warm, very warm. It hovered in and out of the bays, and found it very hot. It was right on the surface.

"I simply cannot stand the heat," it moaned.

And it couldn't.

In the twinkling of an eye it burst and rose on the warm air in tiny particles, higher and higher, climbing a sunbeam. And all its particles mingled with those

of its neighbours. It was vapour now. When the sun set, it grew cooler and people looking up said, "It is clouding over, up there."

But another day came. The sun shot down its scorching rays, and the clouds disappeared, but the vapour was still there, though unseen. For hot air, as I said before, can carry more unseen vapour than cold air. One day it was near the mouth of the Mississippi River. The next day it was following up the river. It was very, very warm. And more and more particles of vapour rose from the river to join the throng.

"It is terribly hot," said a man down on the Earth, mopping his brow.

"It is the humidity," said his neighbour.

Farther and farther up the Mississippi the vapour travelled. Once or twice in the coolness of the evening it was visible as clouds, and then it disappeared again.

"An area of low pressure is coming up from the South," said the Weatherman, and the barometer fell. For moist air is lighter than dry air.

The vapour-filled air found itself near the Canadian border and, in the shoving and jostling of the clouds, floated a little higher or lower, and was struck in the face by some colder air. That, it just couldn't stand. All the particles ran together and formed drops and down they came.

"Rain," sighed the people below.

"Such a relief!" And rain it did.

Did our drop fall on the Canadian side or the United States side? I do not know. For clouds and water never learned political history, though geography is the breath of life to them.

Swamp Life

Anyway, down it fell. It soaked into the earth, it and other drops with it. Down it slipped from a blade of grass to a dead root. It was in a swamp. For a long time it lay there. Slowly bits of refuse began to dissolve in it, from the dead branches and leaves around it. It became peaty water, yellow, tawny, not pleasant to drink. It was occasionally ruffled by the wind, or blown to one side. It gradually got over to the centre where the lazy water sometimes moved a little, sometimes rested. Slowly it was borne a little farther down, dirty and unhappy, but water just the same. One day the wind gave an extra push. It began to move a little. Why, it did not know. But it was really because away up near the edge of the bog some water had soaked through a part of the swamp barrier and other water was moving up to take its place. Farther and farther it was pulled and shoved, until at the edge a slow stream flowed from the swamp. Glad to be moving again our drop went on. Now it ran more quickly. Some distance down it gurgled over some pebbles, when plop! It struck a stone and was hurled right out of the stream!

Ground Water Life

It lay a while but didn't like the look of the sun, so slipped down beneath the stone against which it had been splashed. Not that it did not like floating as a cloud. It did. But it was having adventures, not always pleasant it is true, but it was seeing the world. Not yet did it want to go back to the clouds. "The ocean is my home," it thought.

It slipped farther down, around this grain of sand

and around that. A number of other drops followed it. Together they sank lower and lower. It took quite a while. It was very dark. But as it slowly filtered through the sand it said to itself, "I am getting clean again, pure and clean."

Down, down, the drops went, now through sand, now slowly, very slowly along little openings in clay, then through sand again.

Until away down there the drop began to hear and feel more and more neighbours around it. Every grain of sand or pebble had water around it. It and the few that were splashed over with it were not alone. They had reached the ground water level.

For almost everywhere beneath the soil there is a level at which water stands. It cannot go farther because the rock or the clay beneath it is impervious. The level may change from time to time according to the rainfall. Or, the level here may be different from the level there, because of the difference in the average of rainfall in the two places, or, heavy clay may block its flow in this or that direction. In another place the flow may not be blocked, so it will flow more quickly.

Our drop did not know it, but it was beneath a farm. Now the farmer wanted more water for his cattle. He decided to put down a well. As the digging and scraping went on, our drop edged farther and farther away. It did not want to go up again to be swallowed by a cow or a pig. That was all very well. It is a worthy fate, "but I want to see more of the world, above and below, and anyway, the ocean is my home," it thought. And shoved its neighbours a bit impolitely.

Just in time!

"Water!" cried the farmer as the water rushed into his well. Up it went!

But our drop had got beyond the pull of that first water to enter the well. It decided to hurry, and first thing it knew it tumbled with others into a crack in the rock against which and over which the soil lay. "Another adventure," thought the drop. "And I am so much cooler and cleaner." And on it went, slowly moving down, pulled by some unseen, unknown power.

And as the water stood or slowly flowed through the rock it was joined by other small seepings of water.

All the way down, and it was a long way, slowly, silently but constantly it was dissolving out mineral matter from the rock, making the fissure wider and wider and then making a network of fissures. And the busy drop of water itself was changing.

It fell from the sky a pure drop of water, soft water we call it. In the swamp it was soiled with decaying life. Filtering through the sand it was cleansed, and here in the fissures of rock it was dissolving out and carrying away mineral matter. It was becoming 'hard' water.

Down it sank through the fissures down to some porous sandy rock. And with it followed all the other drops. Here it slipped around this grain and that, sometimes stopped by grains cemented together.

Suddenly a distant noise alarmed it. A thud, thud! Time after time, thud! thud! Then a pause.

"I know," said a neighbouring drop. "Men are drilling a well in the rock."

"Another well," shuddered the drop. "I thought I

had passed that danger." And it hurried on beyond the spot.

For wells are drilled through rock down to porous rock where large supplies of water collect because it can flow more freely.

Hurry, hurry! Faster, faster! Why, it knew not. When suddenly it burst into daylight in a bubbling spring from a crack in the rock. Pure, clean, cold, fresh water, sparkling in the sunshine.

Some boys and girls came up the trail.

"Hey," shouted the foremost, "here is a spring!"

"Oh," said the drop, "the ocean is my home," and it jumped over a stone down the other side, racing over bright pebbles. It got away. The picnickers drank great cupfuls of drops that were behind it.

On it went tumbling down and down, under a tiny road bridge and into a larger stream. The stream flowed on into Rainy Lake or somewhere else near the border. It flowed on to Lake Superior.

"Oh!" thought the drop, "my ocean home!" But it was wrong. Lake Superior is freshwater and the ocean is salt water. The drop soon realized its mistake, and slowly moved on. How or why it hardly knew, except that all water must flow down to the ocean, if possible.

Sometimes on the surface of the great lake it was frozen into ice. Sometimes for years together it was far down below the freezing level, even in winter, or far out from shore where it never freezes in those great restless lakes. Years and years it took to pass through Lake Superior, Lake Huron, Lake St. Clair, Lake Erie and all the rivers between. Perhaps in places it went by the canals. I do not know.

But it did not go by the Welland Canal. I know, because it came down the Niagara River. Faster and faster it began to run, pushed and pulled. And now it was at the brink of Niagara Falls, one brief moment!

And down below stood a man! A great man, who has found out some of the laws of the Universe. Tall, grey-headed, he stood there looking up. He stood there very still. And in his mind he saw not only the drops, the millions and millions of drops of water that hurled over that precipice, but he saw the many more millions of atoms which made up the drops. His mind reached out to the infiniteness, the endlessness of that number. I know. I heard him tell it. He was Sir Oliver Lodge.

And there was our drop of water just on the edge, when down it plunged, far down below the surface, to be tossed upward again into the Whirlpool. On and on swiftly to Lake Ontario!

Then the drop rested again for many long years. Sometimes it helped bear on its back the big boats that carry the wheat down to the ships that take it far and wide over the world. Sometimes it was whipped in high sport by the wind from the top of a wave, to fall back again. Many, many of its companions were drawn up by the sun to be dropped in rain and go through their adventures again. But more of them slowly made their way down to the St. Lawrence, again to jump and shout and splash over rapid after rapid and then on again. Once it was caught in a power-plant race where its struggle down to the sea helped to turn a great turbine to make electricity go out over the land. On again, on to the Gulf of St. Lawrence, so near the ocean! And one never-to-be-forgotten day our drop was hurried by

the prow of a great ocean liner, by wind and ebbing tide, out through the Straits of Belle Isle, out to the Atlantic Ocean.

"Oh," sighed the drop happily, as it floated on the heavier salt water. "Home at last!"

But home does not last, not for a drop of restless water. It may be taken up by the sun and start its rounds all over again. This time it may be caught in a well, or be a fresh, cool drink for beast or man, or make a plant happy, or hang a dewdrop on a rose petal, or help turn a turbine. It may come up as a mineral spring to which people come from far and wide to be healed. It may soak down near a volcano and be hurtled out as steam. or it may enter into the making of a crystal of molten rock, for it does.

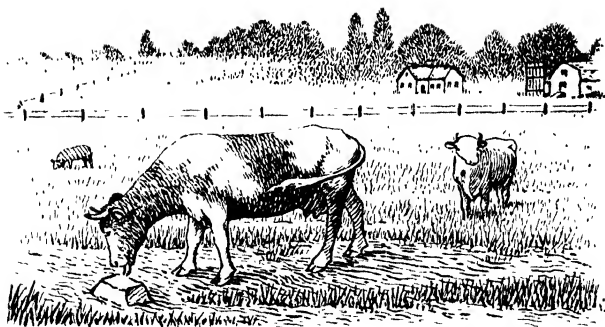
It may do one or other or all of these things again and again. Or, it may, it just may, be caught in a boy's or a girl's experiment in chemistry class and be separated into hydrogen and oxygen. Even then it is not gone. It is just changed into something else. It is never really destroyed! Never!

* * *

It is a great treasure, perhaps the greatest, in the Treasure store of the Earth.

CHAPTER VIII

SALT



ONE SUMMER DAY I lay floating in, or on, Long Island Sound. My eyes were closed in the sunshine, the water lay like a soft mattress beneath! I thought of the many lakes and rivers in which I had swum and floated. But in none was floating like this!

Why? The lakes and rivers were freshwater. Long Island Sound—look at your map—is an arm of the sea. Well, and what is the difference? Salt—just salt!

Salt comes from the rocks. It was in the original material at the birth of the Earth. It is still probably in solution in steam in places within the Earth. You know how easily it dissolves. On the surface the rivers and lakes and the ocean dissolve it, wherever they run over or through or beat against rocks that contain it. There

is so little in the rivers it cannot be noticed. But in the lakes of 'hard' water there is more. And it is all carried to the sea, and left right there on its doorstep. More and more is added every year. And the ocean, poor thing, has no way of getting rid of it. Though it did get even with the land sometimes. When the seas came up over the continents and then withdrew in some cases, they left some of their salt behind.

Just common salt! You put a little from a salt-cellar on your dinner. Your mother or someone else puts it in her cooking. So, you use it for food.

Have you a sore throat? Gargle with salt and water. Have you a nasty cut or open bruise? Wash it gently with salt water. Yes, it hurts, but it is antiseptic. that is, it kills the germs that may have got into the wound. It is really the same thing as a gargle, for there, too, it kills the germs. You use it, then, for medicine.

Is there a spot on a saucepan? Rub it with a little salt. You will be surprised at the result.

Ummmm! Um! Smell it, bacon and coffee for breakfast!

"Is the bacon too salty?" asks mother.

"Oh, no! It is just right," you answer.

"This lot seemed a little salty, so I soaked it a few minutes," adds mother, by way of an explanation of her first question.

What makes the bacon salty, anyway?

Salt is put into it to preserve it. Otherwise it would not keep. And haven't you noticed it in ham? And in fish? That is to 'cure' it. 'Cure' comes from a Latin word 'curare', 'to take care of'. The salt is used to pre-

serve food. It kills the little organisms that would spoil it, just as it kills the microbes in your throat.

And—it is in our bodies! Our very perspiration is salty. You know that. It is in our very blood! Or rather our blood is in it. The blood plasma we give to the Red Cross floats about our bodies in brine. Salt is almost as vital as water!

WHAT IS SALT?

Salt, common salt, is really a mineral called sodium chloride. You know what it looks like—grains, cube-shaped when perfect, clear, translucent. It melts at 1,458° F. or 810° C., and boils at approximately 2,610° F. or 1,450° C. That does not tell you much, does it? It just shows you it is like other minerals, and being a mineral we find it in our Earth's storehouse.

SALT IN HUMAN HISTORY

Did our first savage friend in Persia have salt? Probably not. It is not long since some races in Siberia began to use salt. Their government taught them to use it. The Kirghizes of Turkestan do not use it on their food, nor the Bedouins of Arabia. Some of the American Indians did not use salt when the white man arrived.

These are all people who wander about, nomadic tribes we call them. They live on animal food, milk and meat, whatever they can catch. It is probable that in this food they get what salt they require in one form or another.

Man first used salt when he began to settle down and plant vegetables. But when man wanted salt, want

it he did! And there have been many wars about salt springs.

When more and more tribes became agricultural and accustomed to use salt it became a precious thing, even a sacred thing. The Jews offered it to Jehovah with their first fruits. It was used among the Greeks and Romans with offerings to the gods, and a covenant was sealed over a sacrificial meal seasoned with salt—"It is a covenant of salt for ever before the Lord unto thee and to thy seed with thee," Numbers XVIII, verse 19. A meal with salt was sacred, a friend who had eaten your salt was a friend for life. It is still so among some oriental peoples—"Now because we eat the salt of the palace and it is not meet for us to see the king's dishonour", Ezra IV, verse 14, R.V.

Homer tells of it being used in the feasts of his heroes. The inhabitants of Sierra Leone (look at your map of Africa) used to give everything, even wives and children for it. Among inland people a salt spring was considered a gift of the gods, and even now it is a great luxury. Boys and girls in those regions like to suck it as you do candy.

The Roman soldier was given salt in his ration. When salt was missing he was given something else, usually money, and that was his 'salary', that is, in place of salt. So when your father gets his salary it is his salt money. That was the way the word 'salary' was born. In Abyssinia and other parts of Africa and in Thibet, cakes of salt are still used for money.

Trade Routes

Before there were automobiles or trains, across Asia, North Africa and Europe were well-travelled roads,

along which moved camels or horses laden with burdens. And in early days much of the load was salt. One of the oldest roads in Italy, the Via Salaria, was to carry salt from Ostia to the Sabine country. The caravan roads of the Libyan desert were to carry salt and to-day salt is one of the chief articles of commerce in the Sahara desert.

So important is salt to humankind that from early times until now in many lands governments have raised money by a tax on salt, because it is a tax of which everyone has to pay a small part. Not always a wise way in countries with a despotic government! To get around the tax collector, the salt dealers sold impure salt. But if salt can raise money for governments because everyone has to use it, for the same reason governments use it to help the health of people.

You have a thyroid gland. Did you know that? It is in your neck. Sometimes it goes on strike, or only works half speed. Then the doctor gives you iodine. If you live near the sea, and are eating much sea food you get iodine without a doctor. There is considerable in seawater. Fish and oysters, shrimps and mussels and even seaweed take it up. You get it by eating them. If you live inland you do not get so much, and you need it.

Now everybody eats salt, so the government sees that the salt is iodized, that is, small quantities of iodine are put in it.

WHERE DO WE FIND SALT?

In the Ocean

There is so much of it in the ocean that the water is heavier than freshwater, more buoyant. It will hold you up more easily. If you have learned to swim or float in

freshwater, there is a big surprise waiting for you when you jump into ocean water.

In many countries that border on the ocean the salt is taken from the sea-water.

Go to France or Spain, along the coast somewhere. See that long low shore. Over there are rows of low flat pools, basins rather. They are empty now. We can look at them.

They are fairly level. The one nearest the shore is about at high tide level. The others farther back are just a little lower. The floor of each is covered with puddled clay. Water will not soak through. In some places these salt basins have cement floors.

The tide is coming in. Coming higher and higher up the shore. It can get in down that channel. Now the first big basin is full. Taste the water. Salty, isn't it? The tide runs out. The channel is closed. The water is caught, and no more can get in until it is wanted.

And now the sun begins to work. It is a hot sun in Southern France, and in those other countries where salt is taken from the sea. From the surface of the pool the water becomes vapour and climbs the sun's rays into the atmosphere, but not the salt. It stays in the pool.

Taste it again. Saltier and saltier! There is the same amount of salt, but less water. It is more 'concentrated'. The next basin is a little lower. The water heavy with salt slowly trickles into it. As it gently passes down from one basin to another it becomes more and more salty. Until over here, at the last basin, the salt is falling to the bottom. The water dries up. The salt is left just as it is when salty water is left standing in a glass of water.

In this basin, see, it is raked up into rows and heaps and drained again.

But it is not always pure. Some of the soil gets in it, and there are other salts in it. If only a little soiled it may be sold cheaply. If there is too much other matter it may be washed. Some of the other salts will dissolve out more quickly than our salt, so they can be washed away with freshwater. Then the rest may be dissolved in freshwater which is boiled off leaving the clear crystals of salt.

And believe it or not, in Northern Russia and Siberia they use ice to separate the salt and water. The sun is not hot enough to help them there, at least it is hot for too short a time.

Do you remember the short polar trip we took when talking about water? When stuck in an ice floe in the Arctic we got a drink by melting ice. Did it occur to you that the ice might be salty? It did to me. But very little, if any, salt freezes in the water. It is the water of the sea that freezes not the salt. There might be salt spray on it, but dig beneath.

So the northern Russians freeze their water and take off the ice. The liquid at the bottom like that which was drained from pool to pool in France and Spain, becomes more and more salty.

From Brines

In many countries, India, Russia, United States and in sections of Africa there are salt brines. Imagine ready-made brines down in the Earth!

Hospitals and Sanatoriums have sprung up around salt springs all over Europe and America. Sick people go to get 'treatments'. In the salt springs there are other

salts than the salt we eat. They all help, if not to make people well, at least to make them better.

We, in North America, have known of 'salt licks' all our lives, places where salt springs come out and all the wild animals come trooping down to get their salt.

But, as a rule, the reservoir of these brines is not enough to make salt to sell as salt. There are a few, however, both in Europe and in North America large enough to make it worth while to evaporate the brine for salt.

But we have more brine than that right at the surface. There are places where Dame Nature is making salt all the time. There is the Dead Sea in Palestine. It is becoming saltier and saltier! Even the river Jordan brings more salt into it. And the climate is so hot and dry that the sun gets in its innings. Even though some freshwater comes in, more is lost by evaporation. Some day, probably not in my time nor in yours, but in time it will just dry up and leave a bed of salt.

But we have another nearer home! Great Salt Lake in the State of Utah. Even the shore sand is not sand at all, but salt, real salt! I have driven over it. Once it was used for a motor speed race. It makes such a hard road, never dusty.

There is other salt both in Palestine and in Utah, as well as ready-made brine, in quantities.

And there are other salty waters on their way to become briny in time. Land-locked seas like the Caspian Sea, the Black Sea and the Mediterranean Sea are usually more salty than the open ocean. Of course much freshwater runs into them from rivers, but their evaporation is very great.

Rock Salt

Salt a rock! Yes, it is. In India there are mountains called the Salt Range. Of course they are not all salt, nor even mostly salt, but there is so much salt found there that they have been so named.

Rock salt is called halite. When perfectly formed each crystal is a water-coloured cube. Sometimes when formed very fast it is just outside. a box-like shell.

But from where does all this salt come?

Volcanoes may throw out salt. There is some in the lavas of Vesuvius. But that quantity is small.

The rock salt was left by the seas that invaded the continents. I have seen large cubic crystals or fossil salt in the rocks at the very bottom of Page Two in the Earth's story.

All through the ages rocks were deposited, but would the salt settle out of the water each time, too? Probably not. When the sea withdrew from the continents it probably left basins of salt water just like the Dead Sea and Great Salt Lake, cut off by some barrier. It could not get out. And slowly the water in them evaporated. They became more and more salty. Finally, it was salt, not salt water.

On top of the salt in many places there are thick beds of gypsum. Plaster of paris is gypsum, used to make the smooth surface of plaster walls, or to make models. You know it.

Now, how or why is the gypsum there, and why is it on top?

It, too, must have been in the trapped salt lagoon. Salt will become solid more quickly than gypsum. So when the salt crystallized out, it fell to the bottom, and

the gypsum was left in the liquid on top. When the water was still further evaporated, down would fall the gypsum.

Did you ask me why the floor of the sea is not covered with salt? There is too much water in it. Think of all the freshwater pouring into it. Salt forms in land-locked lagoons where the salt water has been left behind, and where the loss of water by the work of the sun is greater than the freshwater coming in.

Salt Domes

What are they? Plugs of salt would suggest a better picture of them.

If you think of salt settling from a land-locked basin you expect it to be flat or at least basin-like, but these are upright plugs of rock salt. How did they happen? They are not like Lot's wife upright on the surface but beneath the surface, in some cases, far below.

They are not in one country but in many countries, in Germany, Persia, Palestine, and the United States.

Take a large piece of plasticine. Pat it out flat just like a bed of salt after the water has evaporated. Press from the sides and watch it push up. That will give you some idea of what might happen to the salt, if it were so pressed. But the salt beds are covered with firmer rock which breaks and the salt first bows up, then pushes into the cracks. Some people believe that the process by which the salt moves up into the cracks may be the same as that by which glaciers move down when pressed out by the weight of snow and ice above, that is, the crystals pressed upon at the sides have less pressure on top, because the covering rock has been cracked

above it. Tiny particles melt and then re-crystallize in the freer area. Other people think this is not the way at all. Or, it may depend on the amount of water in the salt. More water would make it more mobile. It may be caused in one or both of these ways. Just how it moves we are not sure. But whatever the method, slowly the salt moves up. Certainly, wherever there are domes the rocks have been pushed about, but not by the salt. It is too weak. Other forces must have done the pushing, and the salt has pressed into the spaces. In a region where movement has taken place more than once, the salt may move higher each time.

Oil and Salt

In the States of Louisiana and Texas, oil has been found near these domes. So the oil men began eagerly to look for oil near all salt domes wherever they are known in the world.

But—they were fooled! It is true that some oil has been found near salt domes in other countries, in Persia for instance, but not in the great quantities in which it occurs in the Gulf States, and there is no oil at all near many salt domes.

Now why is that?

Salt cannot make oil, nor can oil make salt. In the Gulf States there were vast reservoirs of oil. When the rocks were pushed up both the oil and salt moved up, because they were both of a nature that could move. In Persia and those other countries there was not so much oil where the salt happened to be formed. And in some places there was no oil at all.

So, it is not that salt and oil are connected but that when they were near one another the same forces made

them move. When oil was present without the salt it moved up, when salt was present without the oil it moved up.

Mining Rock Salt

If it is on the surface, rock salt can be mined like any other mineral. Very pure salt is mined this way in the United States and in Galicia. It is mined in lumps about one foot in diameter, then crushed and sieved, ground between rollers and screened into four sizes. It sounds nice and easy. But it has its drawbacks. When standing around in sacks waiting for you or somebody else to buy it, it goes back into one big mass.

But much of the world's salt supply is buried far down. This salt is mined in a way all its own. It is brined to be mined.

Few other minerals will dissolve so easily in water. Bore-holes are driven down through the overlying material to the salt beds. Freshwater is poured in. It is left until it has dissolved all the salt it can hold and then drawn up again. The brine is then run into large pans, and the water evaporated. In England and in the United States and Canada the sun is not hot enough, so artificial heat is used to evaporate the water. The principle is just the same as evaporating sea-water. From the pans it is raked into rows, and then into heaps to drain and dry, just as described before.

Kinds of Salt

Do you want table salt, sir? All right, we make that by boiling rapidly, keeping it moving. When dried, behold the fine salt!

Do you want butter and cheese salt, sir? Very well, we will leave it a little moist. It mixes better with the butter or cheese.

Do you want fish salt, sir, to preserve your fish for shipping? Over here. We do not boil this, and it forms in larger crystals.

But perhaps, sir, you want a heavy block of salt for your cattle in the field? That is pressed into great cubes. And how the cows like it!

And there are a number of other grades of salt for different purposes.

THE SALT OF THE EARTH

Europe

We have learned that salt is taken from the sea in France, Spain, Italy and England, and other countries with low coast lines. In England deep-lying beds of salt have been found particularly in Cheshire, and there is no longer much made from sea-water.

There are great salt reserves in Austria and Germany which have not been mentioned, just because there are so many everywhere.

Africa

We have spoken of the salt roads in Northern Africa but come with me to South Africa.

We will go to the Transvaal, just about twenty-five miles north and west of Pretoria. Ride out over the undulating bushveld, see that low ridge of land, tree-covered. We can hardly see it until we reach it.

Let us go up the gentle slope.

What a peculiar sight on the other side! A crater-

like hollow, steep-sided, clothed with scrub and grass. Among the scrub and grass are broken blocks of granite. And at the bottom what?

In the centre an irregular dark-coloured pool. From the pool to the edge, what is it? White sand? No, salt! All high above sea-level, in the centre of a continent! They tell me it is remarkably beautiful by moonlight.

From where came this crater full of salt? Is it a crater? Is it a volcano? There is no lava here, just blocks of granite. And there are no sea-laid rocks here. Elsewhere salt has been connected with sea-water.

This is a most peculiar salt pan and that is what it is called—The Salt Pan.

Now, we learned that salt came into the sea originally from the rocks. So it still is in the rocks far down. Waters down there would dissolve it as elsewhere. Steam at great depths would dissolve it. And it is thought that this is a true volcano crater which was blown up by steam only, without melted rock and in the steam were salt solutions.

Asia

We spoke of salt in Northern Siberia. There is some in China, though there has not been much development there from their deep supplies. Practically all countries have salt springs and surface supplies.

Australia

In the year 1829, more than 100 years ago, a ship sailed from Australia, laden with 800 fur seal skins, 400 black seal skins, 2,500 kangaroo skins. Now Australia is a warm country. Skins will not keep long, travelling in those hot regions. They were preserved in salt.

In addition the ship carried two casks (I don't know how large) of seal oil and twenty tons of salt.

There were not many people in Australia one hundred years ago. Certainly there were no salt factories. But on Kangaroo Island there are some natural salt pans. This is what was used. And the climate in parts of Australia, hot and with little rainfall, is just what is needed for evaporating natural salt pans.

There are other sources of salt in Australia. Rock salt has been found in considerable quantity and in some parts salt is obtained by evaporating sea-water.

South America

There is salt in Peru. In fact, there is salt all along the Pacific slope of the Andes Mountains. But not much has been told about it yet, although it has been known for a long time.

North America

There is an almost limitless quantity of salt in the United States. In some places it is a brine, in some places rock salt. Rock salt occurs in Michigan, New York, Ohio, Kansas, Louisiana, California, Texas, Utah, and Virginia. Brines, too, occur in all these States except Louisiana and Virginia. But Louisiana doesn't need it.

You remember we spoke of the salt domes of the Gulf Coast which at first made people think there was some connection between salt and oil? In Louisiana there are two great fields of domes, which seem to be connected with the Texas domes. The source beds are nearly 12,000 feet below the surface. The crystals are shaped by much movement, and it is hard to tell on

what Page of the Story in Stone the salt lagoons were left behind when the sea retreated, because the salt has migrated up so high into much younger beds. Across New York and Ohio is a salt-bearing horizon with great supplies. It is even called the Saline formation, which means the salt rocks.

I am sure I have missed some places. If you live in a State which has not been mentioned where there is salt, just forgive me. There are so many.

We saw a peculiar salt pan in South Africa. Now let us go to Oklahoma. The country is flat, with just a few low grassy hummocks, a little higher than the plain. There is no leaf of grass on the plain and the floor is silt and fine sand. If we go on a rainy day it is just an ordinary plain, though horribly dreary. If we go again on a bright day it is covered with a gleaming glistening crust of salt crystals, reflecting back the sun like snow.

From where does it come? There are no salt springs around. But dig a hole and you get brine. It is thought that perhaps some porous salt-bearing bed is so tilted that its contents ooze into the area below the plain.

In Canada there are also many sources of salt. Comparatively recently a bed of rock salt was found at Malagash, N.S. Its thickness cannot be exactly measured but it is more than 300 feet and less than 500 feet thick. And there are brines in Nova Scotia and New Brunswick. So far no large supply had been found in Quebec, though some springs are known. The salt of Western Ontario, both brines and rock salt, has been known and used for many years. Because Ontario salt has been near the railways, roads and shipping, it has

been carried far over Canada, to those places lacking salt or where it has not been developed.

Salt is not new to Manitoba, but a bed has been found buried under 1,500 feet of overmantle. So, now Manitoba salt for Manitobans!

In Saskatchewan, Alberta and the Mackenzie Valley numerous salt springs probably mean an underground supply, but Alberta has also a deep-seated bed 400 feet thick, as yet, undeveloped. It lies right upon those ancient rocks of Page One in the Story in Stone. British Columbia has some rock salt but far from rail head, so most of British Columbia salt comes from California.

And so North America is well salted.

* * *

There are many, many other treasures in the Storehouse of the Earth. If I were to tell of them all, the books would make a library. These are only a few of the everyday ones. So common are they that we almost forget they are treasures. But they are. Great Treasures!

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